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ABSTRACT

Designed to provide teaching materials for middle school and junior high school teachers in northern New England, this marine education unit presents teacher-tested ideas and activities for use in the classroom and in field trips to the shore. Each unit includes ideas and activities drawn from a variety of content areas so that teachers of many different subjects can make use of them. Important concepts include the diversity of natural algae communities, and the complex interactions of marine algae with people and the natural seashore environment. Students learn about these complex interrelationships by studying classification, algae species found in the Gulf of Maine, reproduction, ecology, uses of marine algae in the economy, the history of marine algae, the culture and preparation of algae, and the nutritional value of seaweed. The bulk of the unit consists of student materials and activities including games, identification keys, arts and craft ideas, a crossword puzzle, maps, an illustrated field guide, word/phrase lists, game score forms, challenge cards, life history diagrams, puzzle sheets, tests, lists of algae uses, and tables. Teacher resources include an annotated bibliography of over 40 books, articles, periodical sources, and films. (LH)

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Do You Know Our Marine Algae?

A Marine Education Infusion Unit

Units Revision Team

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SE 041 799

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Revised Marine Education Infusion Units for Middle School-Junior High School

Have You Been to the Shore Before? A Marine Education Infusion Unit on Seashore and Aquarium Life

What Adventures Can You Have in Wetlands, Lakes, Ponds, and Puddles? A Marine Education Infusion Unit on Wet Environments

What is our Maritime Heritage? A Marine Education Infusion Unit on Ships and Shipping

Is Our Food Future in the Sea? A Marine Education Infusion Unit on Aquaculture and Sea Farming

How Do People Use Lighthouses and Navigational Charts? A Marine Education Infusion Unit

Do You Know Our Marine Fish? A Marine Education Infusion Unit on Finfish of the Gulf of Maine

Do You Know Our Marine Algae? A Marine Education Infusion Unit on Algae of the Gulf Of Maine

What Are The ABC's of Marine Education? A Primer for Introducing Marine Education in Your School

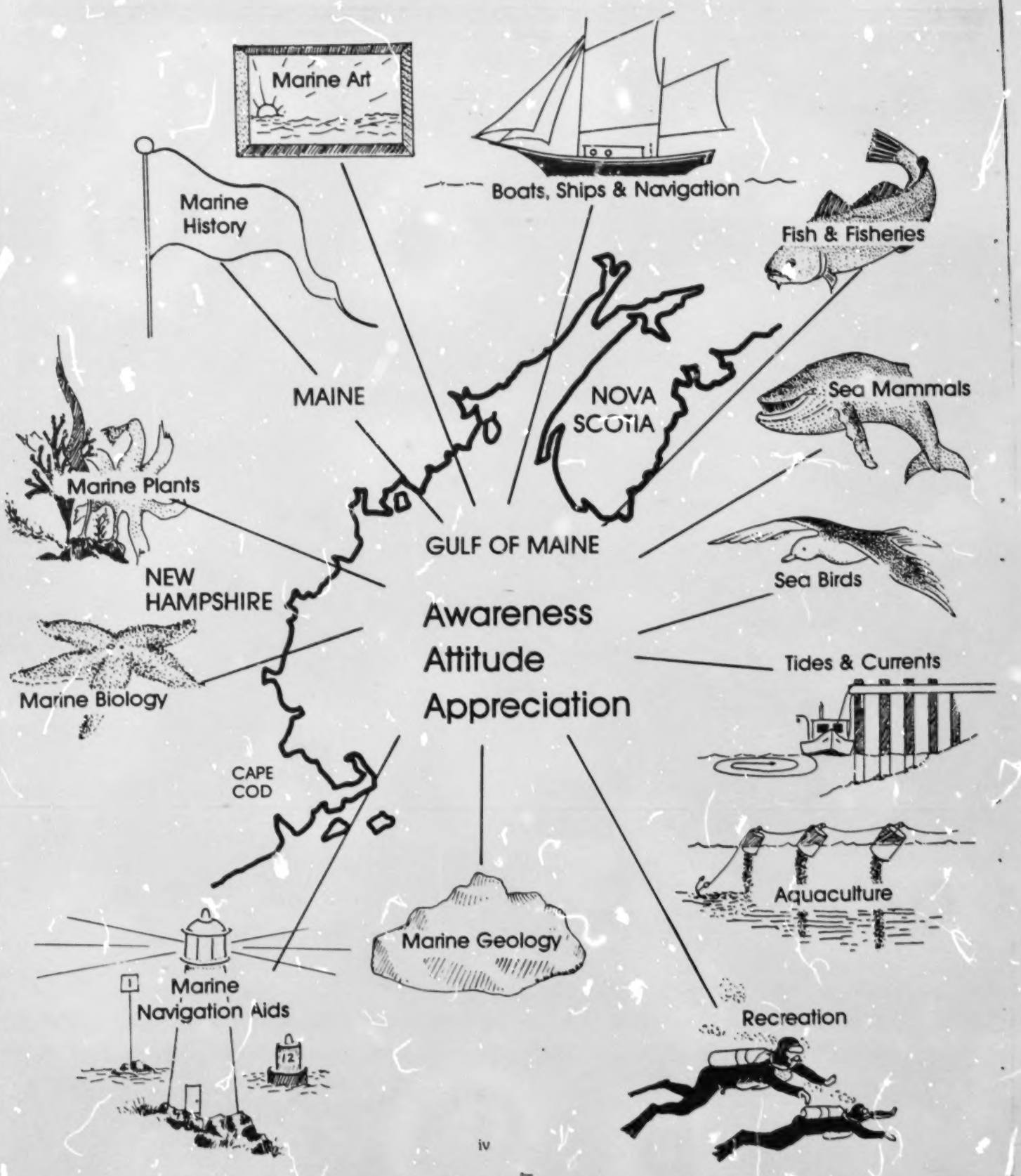
Original — Trail Editions (For Grades K-12)

Clams and Other Critters
Marine Art
The Aquarium
The Beaver
The Lobster
Whale Multi-disciplinary Studies
Our Heritage of Ships
Shipping, Ships and Waterways
The ABCs of Celebrating Year of the Coast in Your School
Have You Ever Been to the Shore Before?
Blue Mussel
Lighthouses
Wetlands
Seaweeds
Aquaculture
Navigation

More than one hundred teachers and members of past NSF sponsored summer institutes have trial tested and critiqued these units.

Marine Education

Ocean & Coast Conceptual Scheme



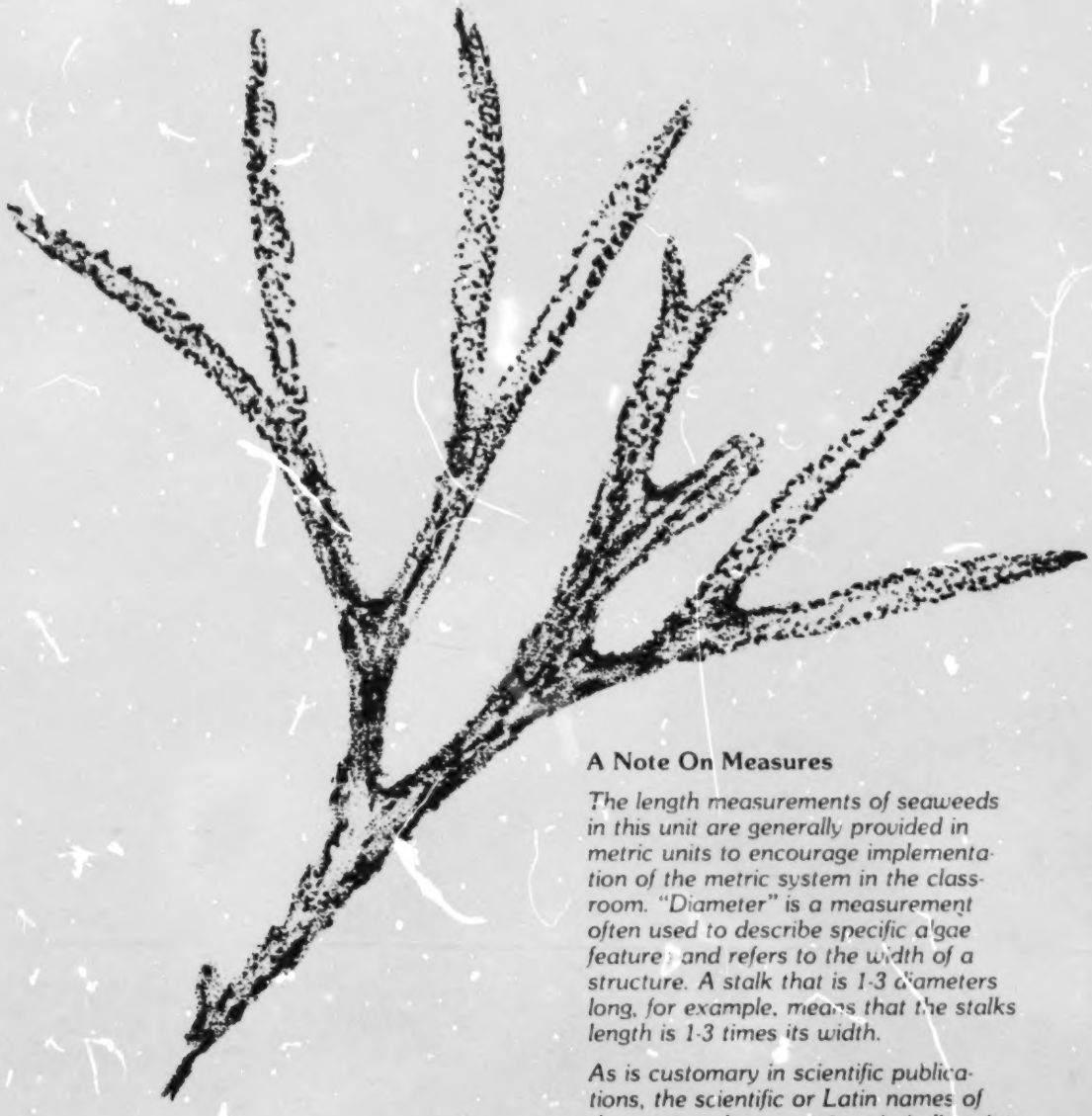
Foreword

Marine education is a relatively new term embracing a multi-disciplinary approach to learning about the marine environment: how it relates to people and how people change and relate to it. These units are intended to serve as points of departure for teachers and students who desire to increase their awareness of the watery world of this blue planet. Each unit includes ideas and activities drawn from a variety of content areas so that teachers of many different subjects at the junior high and middle school levels can make use of them. These units may be used in their entirety or used as idea or activity sources to infuse into the usual curriculum.

Our objective is to help teachers make learning more water-related. We did not plan a structural sequence of topics for grades five through nine, but rather offer these teachers guides and student pages for your consideration.

The general focus within these units is the Gulf of Maine. As the Gulf extends from Cape Cod to Nova Scotia it washes an extremely long and varied coast. We have dredged and seined themes from the activities, concerns, organisms, vessels, and the past of this vast watery region of North America. We aim to be inclusive rather than exclusive, suggestive rather than factual, and stimulating rather than expert. Our hope is that your students will become more questioning, interested, and critical of watery concerns. We hope your use of these materials will add water back into our culture.

John W. Butzow



A Note On Measures

The length measurements of seaweeds in this unit are generally provided in metric units to encourage implementation of the metric system in the classroom. "Diameter" is a measurement often used to describe specific algae features and refers to the width of a structure. A stalk that is 1-3 diameters long, for example, means that the stalks length is 1-3 times its width.

As is customary in scientific publications, the scientific or Latin names of the marine algae are given in italic print in the ***Genus species*** *format. For example,* ***Chrondrus crispus*** *is the scientifc name for the common Irish moss plant. Many marine plants do not have widely accepted common names, therefore only the scientific name is used here.*

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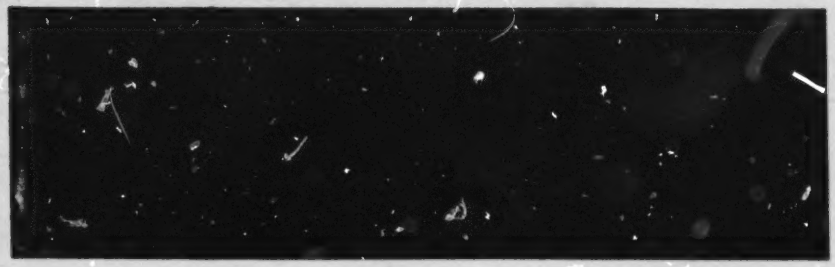
Seaweed

When descends on the Atlantic
The gigantic
Storm-wind of the equinox,
Landward in his wrath he scourges
The toiling surges,
Laden with seaweed from the rocks;

From Bermuda's reefs; from edges
Of sunken ledges
In some far-off, bright Azore;
From Bahama and the dashing,
Silver-flashing
Surges of San Salvador;

Ever drifting, drifting, drifting
On the shifting
Currents of the restless main;
Till in sheltered coves, and reaches
Of sandy beaches,
All have found repose again.

Longfellow



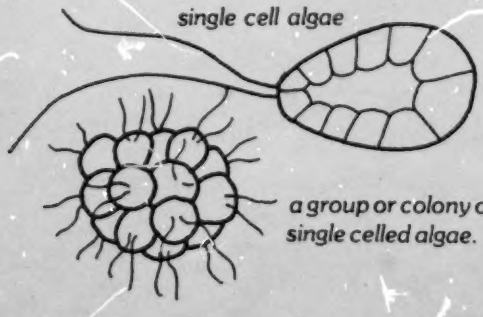
The broad purpose of marine education is to develop a marine literate citizenry; that is to educate our students about the fundamental importance of the connections of human culture to the marine aquatic environment. The general purpose of the marine education infusion units in this series is to provide teaching materials to make this broad purpose possible for middle junior high school teachers in Northern New England. The special purpose of "Do You Know Our Marine Algae?" is to make available teacher-tested ideas and activities for use in your classroom and in your field trips to the shore.

The important concepts in this unit are the diversity of natural algae communities, and the complex interactions of marine algae with people and the natural seashore environment. Specific objectives are given for each activity. Students should develop improved knowledge of marine-algae facts, concepts and principles, as well as an awareness of potential careers and the development of cognitive skills. The increased appreciation of the beauty and complex-interrelatedness of life at the shore will not only be observed in the science classroom but will also appear in art studies, historical understanding, cultural and social fields, and vocabulary development.

This unit is not a step-by-step piece of curriculum; it is designed to allow flexibility on your part. The activities suggested are for use in the field as well as the classroom. It will be necessary for the teacher to adapt the material to the student's abilities and needs, your access to materials, and the availability of transportation for field trips. While this unit does not attempt to answer all the questions on Marine Algae, the methods for teaching this topic will provide the instructor with a solid beginning and understanding.

An Introduction to Marine Algae

The Marine Algae include those salt-water plants more commonly known as sea scums and seaweeds. They may be composed of one cell (unicellular), many one celled organisms (a colony), or one plant composed of several cells (multicellular). The single cell marine algae are only visible under a microscope and require special preparation for their study. The colonies may be visible to the eye but careful microscopic work is also required to understand the complex disorder to their form. The multicellular — or macroscopic algae — are visible to the unaided eye and this trait allows students to observe and manipulate them for an easy beginning to several possible activities.



a group or colony of single celled algae.

The seaweeds are the small to very large plants seen on a visit to the seashore. They are often called the most important group of organisms on earth since they supply the countless numbers of marine animals with nutrition. The best way to study the marine algae is to begin with an organized trip to the sea shore. There, students can view the algae in its natural habitat and closely examine each species by using the "hands-on" method of study. If limiting factors prevent a group trip to the shore, the instructor may wish to visit the coast alone and return with seaweed samples and observations for classroom use.

Marine algae differ from other plant life by: (a) the way they are suited for a salty, underwater existance, (b) having plant structures called blades, stipes and holdfasts, instead of leaves, stems, and roots, respectively and (c) not possessing any specialized cells designed to carry nourishment throughout the plant.

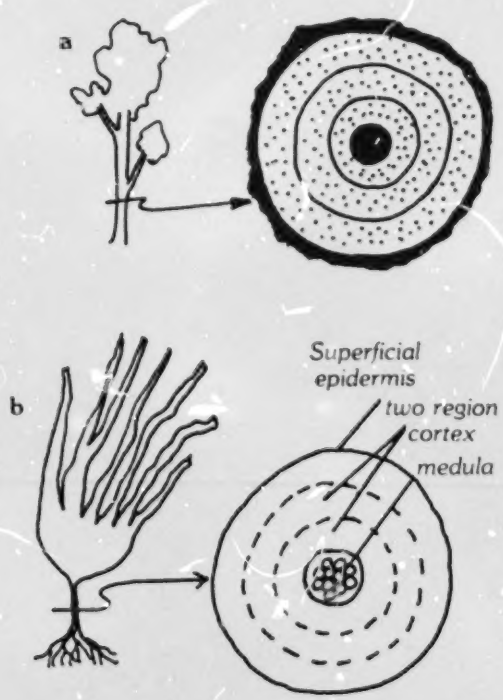
When comparing the anatomy of a land plant and a macroscopic algae it is easy to see why the algae are called 'primitive' plants and why the land plants are called 'advanced' or specialized plants. The algae holdfast resembles the root system of a land plant, but cannot be called a true root system because it does not penetrate the surface of its substrate (the area it is attached to) and has no vascular system to transport nutrients into the

plant. The holdfast functions as the basic organ of attachment and must anchor the plant during storms and strong currents or the algae will separate from its substrate and eventually die.

The stipe connects the holdfast to the blade. Since there is no vascular system in marine algae, which is characteristic of the land plants, some of the more predominant stipes have elongated cells that suggest the possible transport of nutrients (example are the kelps). The stipe must be very resilient as it usually takes the brunt of the wave action. Many times it will be difficult to find a plant's stipe and some algae exist without a stipe (an example is sea lettuce, *Ulva*).

The blade resembles the leaves of a land plant and is actually a flattened, elongated thallus or plant body. Like the leaves, the blade functions as a light receptor obtaining the energy needed for photosynthesis. There are great variations among the blade sizes and shapes and almost every species is characterized by a different blade style.

Higher Plant-Macroalgae Diagram



The top diagram (a) is a cross section of a three-year-old woody stem showing the different regions of specialized cells used in transporting food throughout the plant.

The bottom diagram (b) shows a cross section of a kelp (Laminaria) stipe with the superficial epidermis, a cortex composed of two regions, and a central medula.

Classification

The major groups of visible (macroscopic) seaweeds are the green algae (Chlorophyta), the brown algae (Phaeophyta) and the red algae (Rhodophyta). This type of classification is based upon the pigments within the thallus and is used here along the plant's body type and composition to determine a simple breakdown of the algae groups. An identification key (provided in the pocket section) is a good aid to follow the structural groupings of the different seaweeds. Other forms of classification may include motility, cell-wall composition and stored reserves for photosynthesis.

Gulf of Maine algae species

A Marine Algae Field Guide

In the pocket section of this unit are pictures and descriptions of twenty of the more common sea plants along the Maine/New Hampshire coast. This guide is extremely useful when examining and identifying the marine algae along the sea shore or in the classroom. The use of this field guide should begin with an examination of the pictures provided and comparing these pictures with the algae species in question. To support the findings from the picture comparison apply the accompanying written description, in detail, to the marine plant. Once all the above criteria are met the plant can be properly labeled.

Reproduction and Life Histories

There are two basic types of reproduction seen among the algae. These types are used with variations among certain species. First, asexual reproduction, is the reproduction without the joining together of two sex cells. The second type is sexual reproduction, which occurs in plants capable of producing specialized sex cells (eggs and sperms).

Asexual reproduction in algae is carried on through special cells called zoospores. Zoospores have flagella which provide movement in the water and allow them to swim away from a parent plant to germinate (grow) when favorable conditions occur. Each spore cell contains most of the typical cell organelles. Zoospores are characteristic of sea lettuce, filamentous algae and many species of

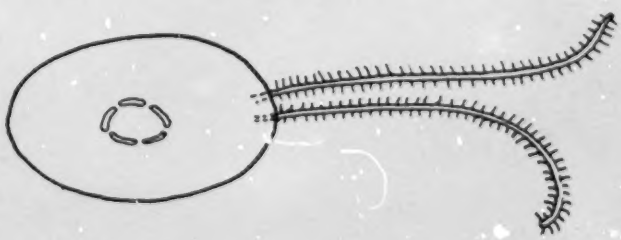
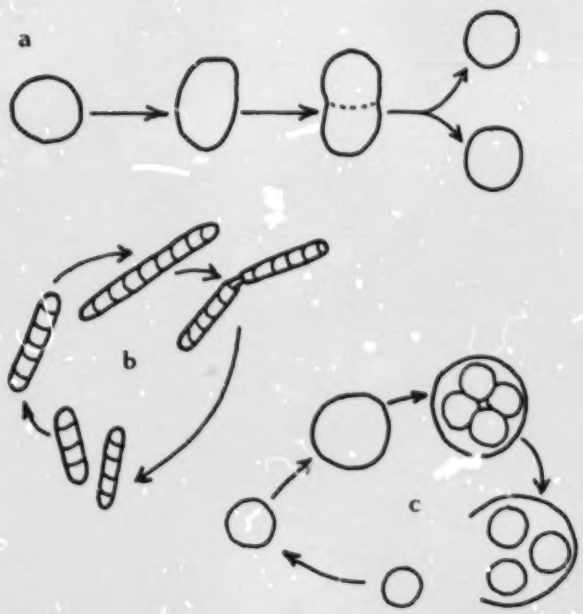


Diagram of a motile spore magnified several times. Note the presence of flagella used for locomotion.

brown algae. Fragmentation is a type of asexual reproduction where individual cells or filaments divide to form new colonies. Fragmentation can be observed among the hollow green weeds, the tubed red weeds, the filamentous algae (once again) and the *Sargassum* weeds, commonly seen south of Cape Cod, which are interesting natives of the vast Sargasso sea.

Reproduction



Algal reproduction by (a) cell division, (b) fragmentation and (c) spore production.

Sexual reproduction involves the production of special sex cells or gametes. Some algae produce gametes of equal size, form, and motility (called isogametes), which are seen in isogamy sexual reproduction. Other species of algae produce gametes of unequal size and motility. These are called heterogametes and are used in anisogamy sexual reproduction. Oogamy sexual reproduction also employs the use of heterogametes where the male cell (sperm) is small and motile and the female cell (egg) is large and nonmotile. The gametes unite, or fuse, in the process of fertilization to produce a zygote (a fertilized egg), and under favorable conditions, the zygote will form a mature plant.

Sexual reproduction occurs at the end of a growing season when the reproducing plant has reached maturity. The end of the growing season varies with the individual sea plants but the green plants usually reproduce in the early summer months, the reds towards the end of summer, and the browns in early autumn. Unfavorable or critical changes in the environment may also bring on reproduction during any season.

The algae life histories differ among species and may use a variety of the above reproductive methods. For simplicity only three general life histories are discussed, and the diagrams provided in the pocket section should be used for a better visual understanding. However, the teacher should be aware of the often quite complex life cycles or life histories that many sea plants follow.

The first example is of the green algae, sea lettuce or *Ulva*. The sex cells (gametes) are produced from the mature sexual plants (gametophytes) and join to form a fertilized egg or zygote. This zygote develops into a spore producing asexual plant (sporophyte). Once the spores are developed and released into the water they begin to form the gametophytes and the cycle continues. This is a typical example of 'alternation of generations.'

The second example is of the brown algae, rockweed or *Fucus*. Here the gametes are produced from special sex organs in the plant called receptacles. These gametes are of different size and motility (oogamy) and are released into the water to fuse and eventually develop into a mature plant. No alternation of generations takes place.

The third and slightly more involved life cycle is of the red algae, tubeweed or *Polysiphonia*. Here the male gamete (sperm) is released from the gametophyte into the water and eventually lands on the female reproductive structure. Fertilization takes place within this female structure until reproductive cells (or carpospores) are produced and released into the water. Now alternation of generations takes place; a tetrasporophyte is formed that produce another type of spore (a tetraspore) and these spores develop into the sexual plants or gametophyte where the cycle is completed.

Ecology of Marine Algae

Before a discussion of the marine algae ecology can begin, the teacher should be familiar with the section on the *Types of Shores* presented in the Northern New England Marine Education Project (NNEMEP) unit entitled "Have You Been To the Shore Before?" pgs. 2-6. Here, a good explanation is given of the different kinds of shores seen along the New England coast plus examples of zones and the variety of organisms that may inhabit these zones. The marine algae zoneation diagram in the pocket section should also be referred to.

Several ecological factors influence the growth and development of marine algae. Seasonal changes produce a wide range of temperatures and atmospheric conditions that affect algae production in many ways. The cold months of November through February hold species growth dormant while the oceans' ice flows may actually scour intertidal

zones, and/or reduce the sun's light-ray penetration needed for photosynthesis. As the snow melts, new nutrients are carried from land to the sea nourishing the coastal algae beds. The spring months of April to June provide more intense sunlight and warmer waters to the algae. These factors initiate growth and reproduction that may also be observed among the land plants. July to September are Maine and New Hampshire's warm months. The sun warms the oceans to maximize growth. As the tide receeds daily and the sun's rays beat down upon the algae, care is provided by certain plant species (sea lettuce, tubed green weeds, kelps and rockweeds) to avoid dehydration and death. Over-exposure is tolerable by these special species, while other algae must remain submerged most of the time. The fall months mark an end of the growing season. Special protective layers or sheaths begin to form on the exterior of some plants and fertilized eggs. This sheath guards against the cold of the upcoming winter months.

Other ecological factors include substrate, storms, currents, and people. The substrate is the surface by which the plant attaches itself. If it is not a secure substrate (sand, mud, or a loose shell), strong ocean currents or stormy weather may toss the plant about until it is destroyed by abrasion on rocks or wilts away on the exposed shore. A strong substrate (boulders, pier pilings, oil rigs) will insure protection from these factors. Humans collecting seaweed for personal use or harvesting have destroyed many productive seaweed beds. It is essential that when seaweed is gathered, enough of the plant (especially the holdfast) is left for regeneration purposes or this important part of the ocean's ecosystem will be lost forever.

Uses of Marine Algae

Economic Importance of Marine Algae

People have always been turning to the sea in search of materials which can be produced more economically than those from terrestrial regions. The sea farming business provides our society with a realistic alternative to the current high energy level of food consumption. The list of seaweed uses in industry, medicine, and food is constantly growing (see lists of algae uses in the pocket section). Presently there are a few industrial companies studying currently used and potential products. One good example (and a possible field trip — see Teacher Resources Section) is Marine Colloids, Inc. in Rockland, Maine.

The State of Maine's Department of Marine Resources issues resident and non-resident sea moss (Irish moss or *Chondrus crispus*) collecting licenses for the commercial seaweed harvester. The seaweed harvester license table, in the pocket section, shows the number of seaweed harvester licenses issued from 1973 to 1979. It is interesting to note that in 1973 only 0.7% of the total Marine Resource Licenses issued were for seaweed harvesters. The sea moss landings table, also in the pocket section, lists the sea moss landings in Maine for 6 previous years dating back from 1980.

The following is a list of the major algae products and properties and their importance in today's industry.

1. Algin Along the coasts of the United States and other countries, red, brown and green algae are gathered for food purposes. Economically speaking, a very important substance, algin, is extracted from different types of brown algae (Phaeophyta). Some of the brown algae harvested for alginates in various parts of the world are listed below.

Algae	Area Found
Common kelp & wrack weed	*North American coasts*
Giant kelps	*California coast*
Rockweeds	*Black Sea*
Japanese kelps	*Japan coasts*
Giant kelp and Japanese kelp	*Australian coasts*
Giant kelps and rockweeds	*South America coasts*
Common kelp and Japanese kelp	*South Africa coasts*

Alginic acid and its salts have colloidal properties allowing them to absorb large quantities of water. One tablespoonful of algin dissolved in a quart of water will make the water so thick it can hardly be poured. Such an important property as this makes it an important product to a number of industries. A teaspoonful of algin added to a gallon of ice cream prevents the water from forming coarse ice crystals. This product also holds the moisture and prevents the icing on cup cakes from sticking to cellophane wrappers.

Algin also has unique suspending, stabilizing and film-forming properties which make it valuable in other processes as well. It is used in the pharmaceutical industry to suspend drugs and antibiotics, such as penicillin. Another use is in auto polish to suspend the coloring matter and to give a uniform product which can be spread onto a surface without leaving brush marks.

2. Agar The sources of agar are from a variety of red seaweeds — Irish moss, *Gigartinas* and *Gelidiums*. There are many methods of extracting agar from seaweeds, but the usual method is with hot or boiling water. The resulting extract is then refined with active carbon, filtered, and then the filtrate is allowed to set until it forms a gel. This gel (or gelatin) is purified by a freezing process, with the water carrying the impurities off during the thawing process.

Agar has a variety of uses in commerce and is also very important in microbiological laboratory studies.

A one to two percent solution will give a satisfactory gel which, in the presence of different nutrients, cannot be eaten by tiny bacteria. Because agar is non-toxic is has been used widely in the food industry for canning meat and fish. It is being used in small quantities in other canned foods and cereals. Another popular use of agar is as an emulsifier (a suspender of one liquid into another) in laxatives. It is also used in many of the same ways as the alginates and carrageenans.

3. *Carrageenan* Carrageenan is used extensively in many food, pharmaceutical, brewing, leather and textile industries. Large sources of carrageenan are found in the Irish moss (*Chondrus crispus*) and *Gigartinas*, which are located in the intertidal zone in the Maritime Provinces of Canada. Other species exhibiting similar colloidal (suspending) properties as the above are dulse, *Dilsea* and *Bangia*.

Carrageenan is principally used in making modern food products more palatable and attractive. They perform such functions as thickening, gelling and suspending. In these applications they are considered as food additives rather than as food itself. The refined carrageenans from Irish moss and other related red sea plants are manufactured in a variety of grades designed to be suited to particular uses.

4. *Soda, Potash and Iodine* Iodine and potash are gradually losing their importance in today's industry. Present manufacturers are looking for useful by-products from the old iodine and potash producing processes. Below is an abbreviated list of those species used when obtaining soda, potash, and iodine from seaweed.

In Europe the kelps *(Laminaria)*, rockweeds (*Fucus*) and wrack weeds *(Ascophyllum)* are the major groups for soda and potash production. Along the Pacific coast of North America and Canada there are many areas occupied by such laminarians as the giant kelps (*Macrocystis* and *Nereocystis*) and the edible kelps *(Alaria)* which are used as a source of potash (potassium carbonate). Some of the seaweeds rich in iodine are among the brown *(Phaeophyta)*, red *(Rhodophyta)* and a few green groups. The leveling of iodine is usually much greater in the younger plants. In Japan, the groups most often used are kelps, rockweeds and *Eisenia*.

5. *Pigments* The algae contain many pigments that are very important. Chlorophylls (green pigments) and carotenoids (orange pigments also found in carrots) are a few examples. Some other pigments are the zanthophyllis, tannins and phycobilins. The tanning industry has used some species of *Sargassum* as a dye throughout its history. The main importance of these pigments are for their value as Vitamin A, which is present in all marine algae. Several pigments are specific to a species and used for detailed identifying and classifying purposes.

6. *Trace Elements* Seaweeds have been used as a source for trace elements for years. Some of the elements that are found in quantities enough to make their uses effective are copper, zinc, iron, vanadium, cobalt, molybdenum manganese, boron, aluminum and chromium. These have been used to supplement basic fodders and fertilizers.

7. *Fodder* The seaweeds are being used in the maritime areas of the world as a source of food for livestock. Because they have nutritional values, vitamins and other micronutrients, they are being fed to cattle, horses and particularly, sheep. The major kinds of seaweeds used as fodder are the brown and red algae. A race of sheep in Scotland live entirely on seaweed for about ten months out of the year. There are several factories that manufacture stock feed in Europe by using the brown rockweeds of *Fucus*, *Ascophyllum* and a few species of kelp, *Laminaria* as the principal sources.

8. *Fertilizer and Manure* Seaweeds have been used for fertilizer for at least 100 years and probably much longer. The seaweeds used have good nitrogen and potash contents but contain only about one-third as much phosphorus as the farmyard manure. The nitrogen is not freely available and requires some time to infiltrate the soil. For this reason seaweed fertilizer or manure is a slow but long acting fertilizer.

All types of seaweed are collected by many of Maine and New Hampshire's gardeners and applied as fertilizer to a wide variety of plants and crops. It can be applied at any time of the year and can be applied to the soil directly. One method to apply seaweed is to dig it into the soil and rake in some winter rye seed. The rye seed will take root, hold the soil against erosion, hold nutrients and provide a good atmosphere for soil microbiological life.

The seaweed need not be dried or rinsed unless the soil on which it is to be spread is very low in humus. Seaweed's greatest gardening value may be in the trace elements it adds to the soil. It is rich in potassium and has about the same amount of nitrogen as chicken manure. Nitrogen is volatile and when any material containing it is left exposed to the air much of this important element will be lost. Digging the material in will decrease this loss.

Seaweed is very rich and should be spread thinly. It can be applied once every three or four years with manures and spread in the later winter or early spring. Digging in should be done about a month after spreading. Seaweed is low in posphate and this may be the reason a few crops seem to respond poorly. Above information adapted from a *York County Coast Star* newspaper article entitled "How to use Seaweed as Garden Compost," by M. Mather, Sept. 1981.

9. *Antibiotics* Although certain species of algae liberate extracellular products (antibiotics) which inhibit the growth of other organisms, the quantities produced by these plants are not, for economic reasons, able to compete with fungal antibiotics in large-scale production. Some of the microscopic green and other algae are common among the sand of the water work filters and it is suspected that they probably decrease the bacterial count by their antibiotic action. Using algae for antibiotical and medicinal purposes is still a relatively new field and needs more research in order to achieve the best uses of these valuable plants.

10. Diatomite Diatomite is an organic material of algal origin containing approximately 86-88 percent silica. This substance is mined from large deposits of diatoms (tiny, single celled 'glass house plants' composed of silica — phytoplankton) of freshwater or marine origin which were deposited as sediment during the time known as the Tertiary (from the present to 2 billion years ago) and Quaternary (from 2 to 65 billion years ago) periods.

The most important use of diatomite is in the preparation of dynamite. Dynamite is made from liquid nitro-glycerine which is very unstable and can explode quite easily. When diatomite is added, however, it becomes quite safe to handle.

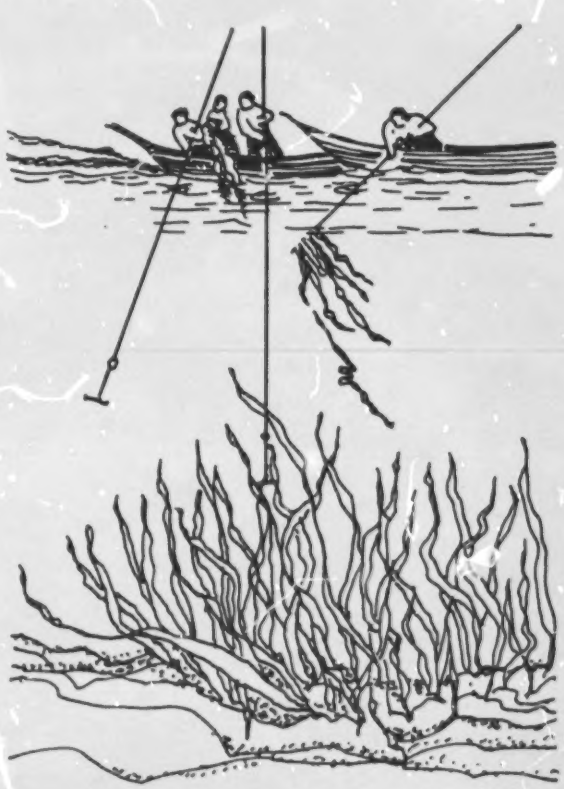
The History of the Marine Algae

No one knows who first started using seaweeds. Marine algae have been used for centuries by people all over the world and can even be traced back to prehistoric oriental times. Some of the major historical functions of algae are as medicines, fertilizers, food for livestock (fodder), and in the early industrial usage. Human consumption of algae will be discussed later.

The first mention of algae as medicine comes from the sixteenth century Chinese. They used certain seaweeds to make herbal 'Pen Tsao Kan Mu' as a cure for goitre. Because of the high iodine content in rockweeds and kelps, various remedies were developed in the Far East (China, Japan, Philippines and the Hawaiian Islands) to treat goiter, sprains, rheumatism, and to aid in losing weight. On the European continent short pieces of kelp stems were, and still are, used in surgery to widen wound entrances. The British used dulse in the eighteenth century to induce sweating during an attack of fever. The Sitka Indians of Alaska had a remedy for headaches that called for placing the thin end of the giant Pacific kelp in one ear and putting the larger end on a hot stone so that steam is generated and passes up the hollow stipe to cure the Sitka's head.

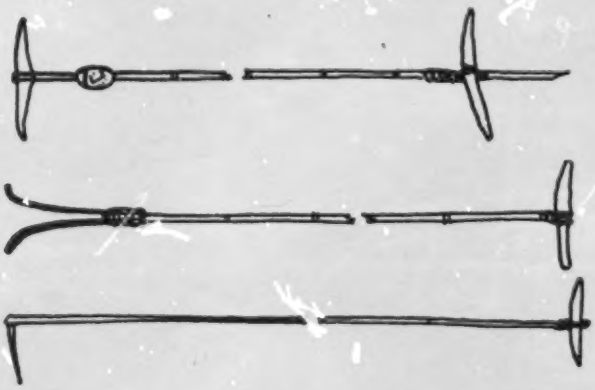
Wherever there were rich algae supplies, historical records show that seaweeds were often used as fertilizer in agriculture. The fourth century author Palladines makes a brief mention of using seaweeds as a partial substitute for fertilizer in western countries. However, it was not until the twelfth century that algae were commonly seen in the gardens along the coastal lands of France, Ireland, Scotland and Norway. Coastal dwellers in New Zealand have also made use of algae in agriculture. The large brown algae were dried and used because of their rich mineral content. In 1885 seaweed formed one-quarter of the total agricultural manure used in Rhode Island, and on the Pacific coast of North America the big kelps are collected and used wet.

Animals have been feeding from seaweeds long before humans began using the marine algae as food. To capitalize on this cheap source of fodder, coastal farmers (especially in Iceland) would collect the algae in the summer and feed it to their livestock during the cold winter months. Many animals preferred to eat seaweed instead of hay or their regular meal, but other animals would only eat a specific algal type. The cows of Iceland would eat dulse and the 'edible kelp' *(Alaria)*; cows from France and the sheep from Norway preferred dulse. In Hong Kong species of *Sargassum* are dried and used as pig-feed, and in Scotland the pigs enjoy the knotted wrack weed *Ascophyllum*. The horses of Iceland preferred the common northern kelp (*Laminaria*). Fresh seaweeds (rockweed and kelp) have been used for animal feeds on the American coast where it is said to have increased the health and fertility of both cattle and poultry.

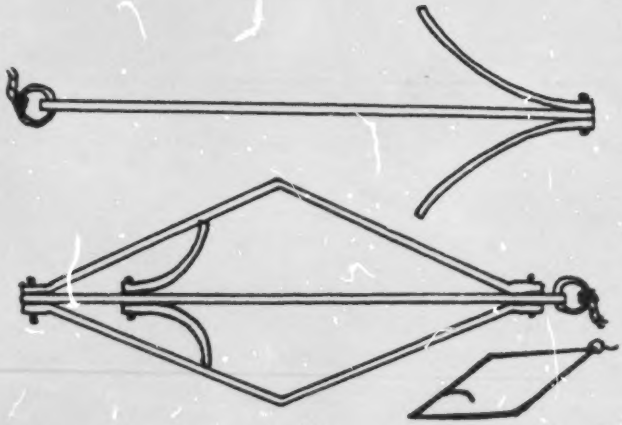


Chopped, dried seaweed has been used with success as an additional feed for cattle on poor pasture lands. Even today much of the seaweed fodder is still fed to livestock around the world.

The history of the seaweed industry dates back to the British and French peasants in the seventeenth century. They began to manufacture soda (for glassware production and in the glazing of pottery) from brown seaweeds: rockweed and kelp. These algae were collected when the tide was out or from the beaches after storms had washed large quantities into shore. The men were in charge of collecting the weeds while the women, children and older family members burned the weeds in kilns after it had been dried. The importation of kelp soda substitutes, after 1810, reduced the need for the kelp industry in Europe.



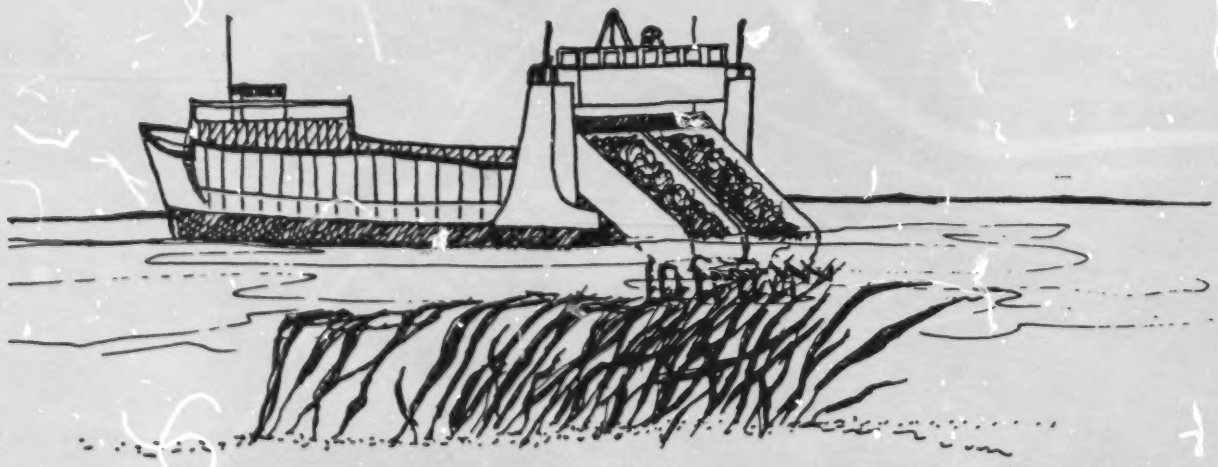
In 1811 the discovery of iodine (important in medicine) in kelp ash revived the algae industry. The seaweed collectors had to get special licenses to cut the plants and they used long poles with sickles attached for this job. Each worker would cut the seaweeds from boats capable of holding ten tons of algae. The industry grew and by 1846 there



were twenty manufacturers of iodine in the Glasgow, Scotland area alone. Japan entered into the production of iodine and was soon producing large quantities due to the availability of a cheap labor force. However, the industry declined a second time when large iodine ore deposits were discovered in Chile. Russia is the only great producer of iodine from seaweeds today.

America first started to pay attention to seaweeds as a natural resource in 1910. At this time potash (a source of salt and soda) was manufactured from large concentrations found in seaweeds rather than digging out the potash from land deposits.

During the Second World War a third revival of the seaweed industry took place. The discovery of alginate, a gelling substance, opened up many new companies all over the world. Even today alginates (known technically as alginic acid and sodium alginate) are produced for uses in food, medicine, textiles and plastics. The seaweeds (giant kelps, common kelps, and wrack weeds) are harvested from modern cutting vessels and the plants are sent to many international companies.



Modern seaweed harvesting vessel

Culture and Preparation of Marine Algae

Cultural Importance

Many countries use seaweeds either in the fried or fresh state, for human and animal food, medicine and other purposes. Their value results from their high mineral and vitamin content.

Seaweeds have been used for centuries in the Far East as a source of food and medicine. In Japan, laver (*Porphyra*) is widely cultivated for its uses as a food product. This seaweed is recovered from bamboo poles that have been inserted into shallow waters. When the algae matures it is removed from the poles and fried. Then it is pressed into sheets and is called Asakusa-hori. Kombu is another dish that is prepared from large laminarians, such as common kelp *(Laminaria)*, edible kelp *(Alaria)*, and *Arthrothamus*. Other foods derived from seaweeds in Japan are Wakame from *Undaria*, Arame for *Eisenia*, Hijiki from *Hijikia*, and Mirz which is made up of the green *Codium* plus a variety of other seaweed.

In the Pacific Islands about 70 species of raw algae of the red, green and brown groups are used as a supplement to many common foods. In the Philippines, species of *Undaria, Sargassum* and *Caulerpa* are used most often. Prior to the nineteenth century the people of the Hawaiian Islands used a wide variety of seaweed for their everyday diet. Upon the arrival of Captain James Cook in 1778 western foods and customs were introduced to the natives with increasing supplies. Gradually the Hawaiian lifestyle changed and the current use of seaweed is at a minimum. In South America the dried and salted species of sea lettuce *(Ulva)* and the giant bull kelp (*Durveilea*) are used in a food called 'cachiyugo.' Seaweeds are not very popular in Europe as a food source, although they are used to a limited extent in a few of the countries.

Seaweed Preparations

Every country usually has its own methods of preparing seaweeds. Below are several preparations and the countries from which they were derived. Some appear to be very appetizing, many are as unique and as tasty as land vegetables, several are to be used as spices, and others would probably only be eaten as a last resort.

1. In the Commander Islands of the Bering Sea, rockweed (*Fucus*) stems are eaten raw while *Laminaria bongardiana* is a main course after cooking it in boiling water for several minutes and then mincing it and flavoring it with onions, tomatoes, salt, pepper, flour and fat.

2. In South Africa the red seaweed, *Suhria vittata* makes an excellent dish. To prepare this dish one handful of seaweed is required. It must be washed and then boiled to a pulp in three to four pints of water. When brought to a boil leave the lid off for about fifteen minutes to allow the fumes to escape. Next, strain through a cloth and add sugar, lemon or orange juice, and brandy or sherry to taste. Additional flavoring can be added by using cloves, cinnamon, and lemon peel, but these must be put into a muslin bag and dipped into the boiling seaweed for about fifteen minutes.

3. In Japan 'kombu' is prepared from *Laminarias*. There are many different processes in arriving at the different types of kombu but these steps have been deleted. In Japan, green kombu is boiled with meat, fish or soups. This can also be used as a vegetable alone or with boiled rice. Powdered kombu is used in sauces and soups or is added to rice in the same way as curry. These two forms of kombu, along with tea kombu, are also used in the preparation of a tea-like liquid.

4. In Indonesia, algae are usually eaten raw after being dropped into boiling water for one minute. They may be eaten with a sauce of allspice, or used with sugar or eaten as a relish, for which purpose they are cooked in sugar obtained from palm trees or soya beans.

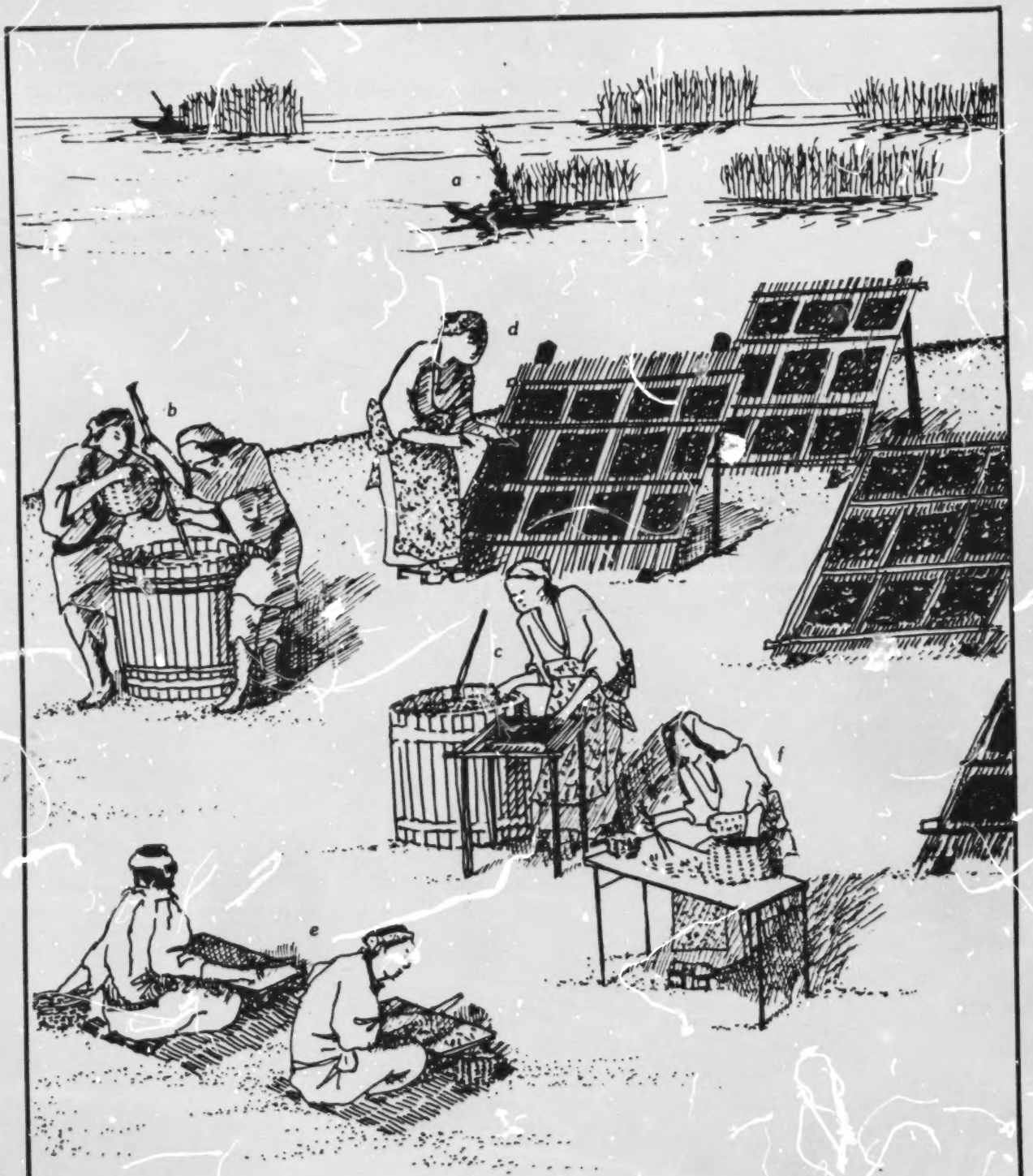
5. Dulse and laver are eaten raw in Greenland or they are dipped in boiling water and eaten with blubber oil.

Preparation of Laver (Porphyra)

First wash laver in fresh water, and then after steaming in fresh water for three or four hours, boil gently until tender. If overdone all of the flavor will be lost, so care must be taken. The water is then poured off and a little salt is beaten into the pulp. This can then be served by mixing with oatmeal and frying it in the form of flatcakes, or it can be mixed with vinegar or lemon juice. Add a few drops of olive oil, pepper, salt and serve cold on toast. Another method is to add some butter, gravy, lemon juice and pepper and heat in an aluminum sauce pan while stirring with a fork. This is then served hot with roast meat.

Nutritional Value of Marine Algae

Today, with the food crisis permeating the world, scientific interest is being focused upon the marine algae as a virtually untapped source of nutrition. Seaweeds will probably play a large role in alleviating at least some of this pressing problem. Recently there is a trend in the United States to certify the edible seaweeds as sea vegetables — a much less objectionable name. These sea vegetables contain a larger concentration of those same essential elements found in the surrounding sea water. This is the key reason their nutritive value



Traditional Japanese preparation of laver.

a) gathering the laver; b) washing the raw weed; c) preparing and d) drying the sheets; e) cutting and f) sorting the dried sheets.

exceeds those found in any other existing food source.

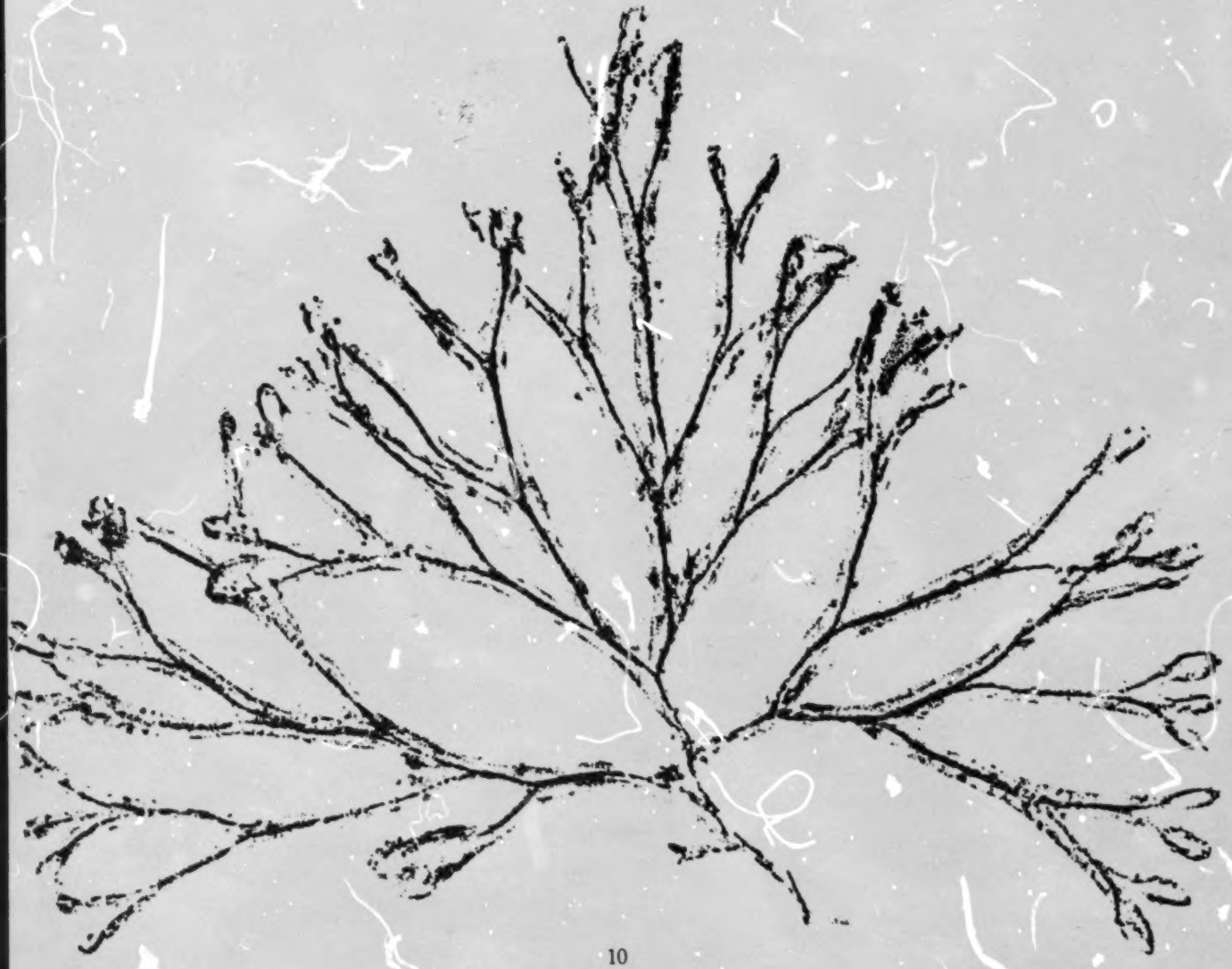
The marine algae are rich in vitamins A, C, E and Niacin, and also contain large amounts of vitamins B12, B1, folic and folinic acids and pantothenic acid. An interesting comparison can be drawn between the algal vitamin B content and the same vitamin B content present in many fruits and vegetables.

Quoting from Judith C. Madlener's The sea vegetable Book,

> [the genus Porphyra *appears to be the richest source, among the algae, of vitamins B and C. In fact, the Red algae* Porphyra perforata *and* Porphyra naidum, *various species of the Green algae* Ulva, *the Brown algae* Alaria valida, *and the Red algae* Gigartina papiliata *share the distinction of possessing, pound for pound, vitamin C values comparable to that of lemons.*

The algae protein content makes up as much as a quarter of its dried weight. Crude protein is highest in the green and red algae than in the brown algae. The protein value of *Porphyra* is higher than the protein value of soybeans or rice, and it would take only one hundred grams of dried *Porphyra tenera* to supply one half of the daily adult protein requirement. Another interesting analogy is to compare the protein and carbohydrate values of marine algae to those of oats...they are almost similar!

The remaining nutritional value of seaweeds is in the form of carbohydrates (polysaccharides) as sugars and starches, minerals, gels, oils and fats with few calories and no cholesterol, and other trace elements.

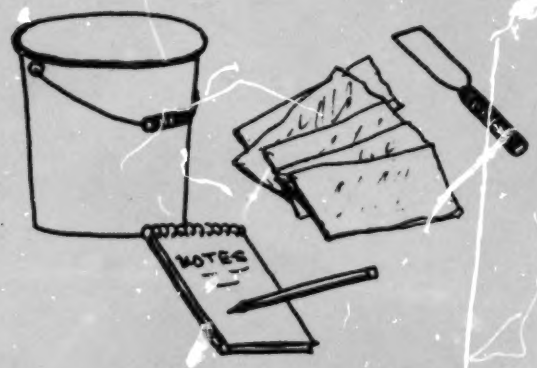


Collecting Seaweeds

When planning a field trip to the shore, either with the class or alone, the teacher should be aware of a few precautions necessary in collecting. Common sense should also be stressed to avoid: (1) being trapped by a rising tide, (2) slipping on the slimy seaweeds, and (3) the uncomfortable cold weather, common along the coast.

Trips should be planned around the low tides. Collecting should begin a couple of hours before the tide reaches its lowest mark. Examine species at the edge of the tide as it recedes, and be sure to wear hip boots or heavy canvas sneakers. Leave the environment as you found it by returning rocks to their normal position, and always remember to carry out the supplies you carried in.

Collecting equipment should include (depending on the number of students), a notebook and pencil, one or more plastic buckets, a variety of sizes of plastic bags, and a kitchen or putty knife. The protected rocky shore line is one of the best spots for collecting. The algae are able to firmly attach to



the rocks, reproduce, and expand in number. A sandy or muddy beach makes a poor substrate for attachment, but here it is common for massive amounts of algae drift to accumulate especially after a storm or high winds. Collecting is also a good time to observe the marine organisms zonation that occurs.

Select only fresh specimens in good condition (avoid old 'bleached' seaweed, yellow or white in color). Place the algae in a plastic bucket or separate the species by putting them in individual plastic bags. They should be kept very moist at all times with seawater for best protection against the sun. Field notes should be taken at the site where the seaweed was collected, and to what type of substrate it was attached.

Many species may begin to deteriorate rapidly when removed from the ocean and must be kept cooled at all times. Depending on the seaweed, they may be stored in a refrigerator from one to seven days. Pressing should begin as soon as possible. A good activity outline for pressing seaweed is provided in the Northern New England Marine Education Project unit entitled "Have You Been to the Shore Before?" pgs. 9-11. Identification of the different species can begin as soon as the plants are pressed and thoroughly dried.

A L G A E

A L G A E is a game played by the rules of BINGO. This game is designed to familiarize the students with algae vocabulary at a fun and easy level. The playing cards are distributed to the pupils along with enough "chips" to cover the word/phrase squares. The word/phrase lists should be cut up so that the individual slips of paper may be randomly drawn from a container (box, hat, jar). The letter (A, L, G, or E) and word/phrase are announced to the class and the students having that word or phrase in the column under the letter should cover up the appropriate box with the "chips." When five boxes in a row are covered (either horizontally, vertically, or diagonally), the student yells 'ALGAE' and is the winner.

The word/phrase lists and ALGAE boards are provided in the pocket section for copying.

Identification Key

Knowing how to use the 'keys' can easily solve many of the problems that arise when identifying the different algae. There are a variety of different keys written on the marine algae, and they all contain the same basic identification concepts. The student using the key is given two or three choices from which to select the best answer. The answer directs the student to another step number in the key where another choice is to be made. This procedure is repeated until the actual species is identified. Often illustrations of the seaweeds are provided with the key. If so, such illustrations are used to verify the results obtained from the key.

The student should then turn to a description of that species (either provided with the keys and illustrations, or obtained from other literature) and verify that characteristics and geographic range fit the organism. Experience with the keys and the many different species is the best solution to the identification problem. A sample key, designed for the common macroscopic algae found along the Maine/New Hampshire coast, is provided in the pocket section of this unit. Below is an example of the steps used to identify Irish moss, *Chrondrus*.

An Identification Key to the Common Gulf of Maine Algae Species

		proceed to #
1.	What color is the algae? green	2
	red	4
	brown	8
2a.	Is the plant body (thallus) a broad blade, solid throughout?	3
2b.	Is the plant body a tubed, narrow blade; hollow inside?	***Enteromorpha***
2c.	Is the plant wiry, threadlike, in loose curls not collapsing flat when removed from water (like horsehair)?	***Chaetomorpha***
3a.	Is the blade firm; 2 cells thick if a microscope is available or fingerprints are undetectable through the plant when a finger is pressed to the opposite side?	***Ulva***
3b.	Is the blade delicate; 1 cell thick if a microscope is available or fingerprints are detectable through the plant when a finger is pressed to the opposite side?	***Monostroma***
4a.	Is the plant body hard and stony?	5
4b.	Is the plant body neither hard or stony?	6
5a.	Is the algae erect, branched and jointed?	***Corallina***
5b.	Is the algae flat, stony and encrusted upon (coating) mussels shells, stones or other algae?	***Lithothamnion***
6a.	Is the algae found growing as an epiphyte (one plant growing upon another) on *Ascophyllum*?	***Polysiphonia***
6b.	Is the plant body flattened with an unbranched blade; two or three cells thick (see easy test in #3 above); no midrib (thickened line of cells in the center of the blade) or veins (branches from the midrib) present?	***Porphyra***
6c.	Is the blade simple (unbranched), lobed (having rounded ends), or branched with veins and midrib absent? Is the thallus *several* cell layers thick (obvious to the unaided eye)?	7
7a.	Does the thallus have two distinct regions: a compressed stalk or stipe and smooth, lobed, flattened dichotomously branched (forked) blades? Is its appearance mosslike?	***Chondrus***
7b.	Is the thallus flattened throughout without a distinct stipe? Are the blades large with dichotomous lobes? Are there one to several outgrowths of branches?	***Rhodymenia***

The color of *Chondrus* is red → so now proceed to question #4

Chondrus is not hard and stony, so follow 4b to #6 → Now proceed to question #6

After examining *Chondrus*, it should be apparent that #6a and #6b do not apply but #6c does. → Now proceed to question #7

The description in #7a should apply to the specimen → Thoroughly apply description of *Chondrus* to your specimen and back up your findings with the picture in the field guide (pocket)

Marine Algae in the Arts and Crafts

1. When pressing algae, substitute clear contact paper for wax paper. The dyes in the algae will stain the contact paper and the print remaining on the paper may be mounted behind a white background (white construction paper) or as a window ornament with a clear background.
2. When pressing brown seaweed, a square of clean, white cotton or linen cloth may also be substituted for the wax paper. This will produce a design on the cloth that can be used for other art exhibits or T-shirts. The cloth must be changed regularly for the first three or four days. Experiment with different species.
3. Pressed Irish moss resembles a bare tree and students may depict any of the four seasons with this 'bare tree' as a building block.
4. A natural oceanic setting can be constructed from pressed samples. Other seaweeds may be added to the pressing or drawings of seaweeds, marine animals or fish may be added to the original.
5. A mobile can be made from certain small species (coral weed, Irish moss, etc.) together with driftwood and sheils. A nice display can easily be constructed...and cheap too!

The Marine Algae Game

(Adapted from "A Plant Identification Game" by Peter S. Bosse. From The American Biology Teacher, Vol. 39, n. 2, 1977.)

The Algae Game is designed to introduce the ideas of classification and nomenclature of the algae without actually using these terms. The reason for this approach is that it eliminates the drudgery and "non-value thinking" students normally associate with taxonomy. It is a successful game in that it provides competition, allows for creative expression, deals with only a single concept area, and introduces the ideas of taxonomy through a hands-on manipulation of materials. The purpose of this activity is: (a) to stimulate interest in the classification of marine algae, and (b) to provide a basis from which to launch similar activities.

Materials necessary for each team of three or four consist of, a small amount of tape for labels, a plastic bag or paper bag for specimens, or mounted seaweed specimens, a pen or marking pencil, and two sheets of paper.

The procedure can be divided, if desired, into an outdoor phase and/or an indoor phase. In the field: (a) collect at least two specimens from each general group of algae (greens, browns and reds); (b) place a numbered label on each specimen, and, on the first sheet of paper write the number and invented name which reflects the dominant characteristics of the plant; (c) on the second sheet of paper make two columns, one containing the numbers of the specimens, not necessarily in order, and one containing the names and characteristics of the specimens, not in order. Sample game cards are provided in the pocket section of this unit.

When all teams have finished these three phases, they exchange specimens and lists of numbers and characteristics. The object is to correctly match the specimens with the characteristics. A time limit may stimulate interest.

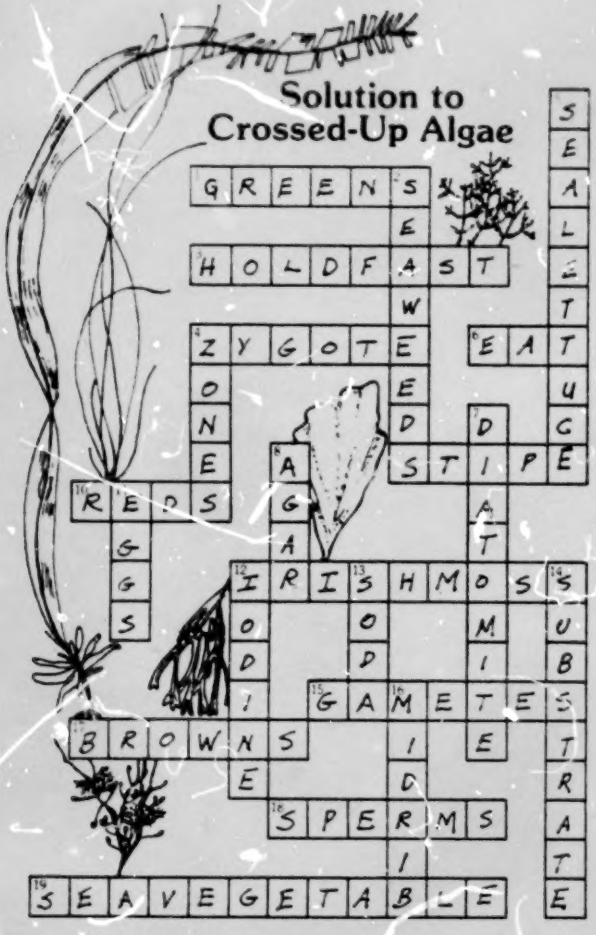
Follow-up may include discussion of the variety of names given for the same plant, accuracy of descriptions, ideas of similarity and grouping, classification, and scientific naming of plants.

The game can be conducted successfully in fifteen minutes, but a double period allows for immediate discussion of results, which is sometimes a favorable situation.

The Algae Game Score Form

Sample Number	*Invented Name*
1	Swiss Cheese Weed
2	Green Paper Weed
3	Air Bubble Algae
4	Green Thread Algae

Sample Number	*Names and Characteristics*
2	Sea lettuce (*Ulva*) — thin, green sheets resembling salad lettuce
7	Rockweeds (*Fucus*) — midribs present, air bladder present, distinct holdfast
10	Horsetail kelp (*Laminaria*) — blades ribless, divided in straplike fingers



Marine Algae Adaptations

Create An Algae

Create an algae is an activity that will enable pupils to recognize that algae are uniquely suited to their habitats. Using imagination students may choose to create an algae from arts and crafts materials or the teacher may assign one of the "topics" as a written composition. The final product should show how the algae are adapted to survive under specific environmental conditions. A sample article is provided along with several imaginative topics for possible use.

The following is a list of ideas that teachers may wish to assign as a written composition, for a science fiction project or an imaginative art design.

1. Create an algae that will float for 2000 kilometers and then settle and grow.
2. Create an algae that will lay flat in storms and swift currents.
3. Create an algae that can move from one zone to another.
4. Create an algae that protects itself from being eaten by fish.
5. Create an algae that is propeller-proof.
6. Create an uncollectable algae (protected from humans).
7. Create an algae that can live in sea and on land.
8. Create an algae that can live during a cold, harsh winter.
9. Create an algae that can live during a dry, hot summer.

Crab Eating Algae Discovered

PORTLAND, MAINE — A new species of crab eating marine algae was found yesterday by lobsterman Bert Johnson. Mr. Johnson first noticed the algae while retrieving his traps. "It was caught up in my trap lines when I pulled it in," Johnson stated. "I knew something was unusual about this seaweed when I saw its funny branches and all the empty crab bodies in the bottom of my trap."

Scientists, after careful examination, describe the plant as a 2 meter tall, brown seaweed with branches resembling human arms. The end of each major branch is in the form of a nut or shell cracker while the smaller branchlets resemble a fork. The new species possess a root-like holdfast and, it appears remains attached to rocks while the unsuspecting crab wanders into its "reach."

Naming the algae caused some difficulty as scientists rejected names like King Crab Consumer, the Voracious Veggie and the already used Crab Grass. The agreed upon name was Krab Killer kelp (genus *Cancer* species *digesticus*). No other Krab Killer kelps have been collected but the investigation continues.

The Whole World Marine Algae Catalog

From the world map in the pocket section have students identify a country or a region of a country, that corresponds with the appropriate letter. Next, have them identify the type of culture in the area and how that culture has used, and currently uses, seaweed. This activity can be used as a library activity or it can be extended into a lengthy take home report.

The following is a list of countries that correspond to the letters on the world map in the pocket section.

A	Hawaii, USA
B	Puget Sound, USA
C	Los Angeles/San Diego, USA
D	Rockland/Scituate/ Rhode Is., USA
E	North Carolina, USA
F	Iceland
G	Scotland, British Isles
H	Ireland
I	France
J	Norway
K	Russia
L	Ceylon
M	Bali
N	Japan
O	Philippines
P	Australia
Q	New Zealand

Marine Algae Epicures

The following recipes are for a classroom meal. Although they require additional equipment (hot plates, pots and pans, utensils) all recipes may, with care, be prepared in the classroom. As an alternative the teacher may wish to assign each dish to be prepared at home and only warmed in the classroom. Although the choice of recipes is left to the discretion of the instructor, it is suggested that several be tried and tasted. The availability of different seaweeds may limit the teacher to certain recipes. Some of these recipes were adopted from the very informative and useful sea vegetable Book *by Judith C. Madlener (New York: Clarkson N. Potter, Inc. 1977).*

Seaweed Soup Stock/Jelly
Laver, edible kelp, Irish moss and dulse can be used in this recipe. The resulting soup is clear and can be used as a nutritious base. First clean the seaweed by rinsing with fresh water. If edible kelp is used, remove its olive-colored membrane. In a pot, cover seaweed with water and boil for 30 minutes. Serve hot as a soup with added seasonings or cooled as a jelly.

Irish Moss Salad
Irish moss
3 lemons
lettuce leaves (or sea lettuce leaves)
2 apples
30 ml celery, finely diced
45 ml mayonnaise
walnuts

Wash in hot water some picked over Irish moss. Place in a pan or bowl and cover it with the juice of three lemons. After several hours the moss will have dissolved, hardening everything into a yellow jelly. Place this in the refrigerator to chill a couple of hours. Arrange a few lettuce leaves on four chilled salad plates. Cut the moss mixture into cubes and place them in the center of the lettuce. Cut the apples into cubes and mix these with finely diced celery and mayonnaise. Distribute this among the four salads and top with walnuts.

Laver and Pork Omelet
8 large eggs
60 ml milk
vegetable oil
4 sheets dried laver or 250 ml dried fronds cut into small pieces
250 ml finely shredded, cooked pork

Beat together the eggs and milk. In an omelet pan (or equivalent pan) slowly heat the oil. Stir in the laver and add the cooked, shredded pork pieces. Stir together, then pour in the egg-milk mixture. Finally, cover and cook over a low heat until done. Will serve about four.

Irish Moss Mousse
125 ml Irish moss
500 ml milk
2.5 ml vanilla extract
65 ml honey
1 egg yolk, beaten
1 egg white, stiffly beaten
250 ml whipping cream

Soak Irish moss in enough cold water to cover for about 15 minutes. Drain and remove any foreign matter (shells, dirt, etc.). Place the Irish moss in a piece of cheesecloth of about 20 centimeters square, tieing up the ends firmly. In the top of a double boiler place the milk and vanilla. Suspend the cheesecloth bag into the milk and slowly bring the liquid to a boil. Reduce the heat and let simmer very gently for not more than 20 minutes. Occassionally press the cheesecloth bag against the side of the pan to release the gel. Stir constantly. Remove from heat and discard the spent bag. Allow the mixture to cool slightly, then add honey. Pour the mixture into a bowl and while it is still warm, stir in the freshly beaten egg yolk. Finally, fold in the stiffly beaten egg white. Spoon this into steamed glasses. Cover tightly and refrigerate. Top with whipped cream prior to serving.

Sample Test on Marine Algae

Below is a sample test on the marine algae. Modification of this test is encouraged to suit particular class needs, however, direct copies from the Sample Test in the pocket section may be used if applicable.

1. What are the three kinds of Marine algae and what makes each one so different?

   A. *Greens (Chlorophyta)*

   B. *Browns (Phaeophyta)*

   C. *Reds (Rhodophyta)*

Each differ in their pigmentation, degree of motility during reproduction, their cell wall composition, their gross structure and plant body type, and the stored reserves in photosynthesis (starches, fats and oils).

2. Name two of the things that industries remove from algae. What is each one used for?

   Can choose from Algin, Agar, Carrageenan, Soda, Potash, Iodine, pigments, trace elements, and antibiotics.

3. Fill in the diagram. Tell what function or use each part has.

Part

a *Air bladder*
b *Receptacle*
c *Thallus or Blade*
d *Stipe*
e *Holdfast*

Function

A. *buoyancy*
B. *reproduction*
C. *photosynthesis receptor*
D. *support*
E. *anchor to substrate*

4. Using the zonation diagram, list those algae common to the zones below. Why are they common to that zone?

   Supralittoral Zone:
   Mostly land or terrestrial plants. Marine algae are present only as microscopic mats (brown or green) due to lack of water/moisture.

   Littoral Zone:
   Rockweed or Fucus, *sea lettuce* or Ulva, *and coralline algae* or Corallina. *These species are confined by the tidal flux and light availability.*

   Midlittoral Zone:
   Green tubed weed or Enteromorpha, *Irish moss* or Chondrus, *edible weed* or Alaria, *and dulse* or Porphyra. *These species are also dependent on tidal exposure (water availability) and the quantity and quality of light exposure.*

   Sublittoral Zone:
   Kelps or Laminarias, *cord weed* or Chorda, *sea colander* or Agarum, *and the flowering plant eel grass* or Zostra. *These plants remain submerged and lack the full spectrum of light received by the upper zones.*

5. From the **world map** name the region or country that belongs to a letter and tell how algae is used in that country.

   The answer to this question can be found in the 'Whole World Algae Catalog' activity and in the teacher background section entitled "The Culture and Preparation of Marine Algae."

6. What is the name of the marine algae in this picture? What color is it? Why do people collect this algae?

a) *Irish moss or sea moss or* Chondrus crispus

b) *A red algae — Rhodophyta*

c) *For industrial use to produce carrageenan, agar or fertilizer*

Exploring for Marine Algae

Objectives: ***To discover and observe the various types of marine algae in their natural habitat. To be able to record the major structures for attachment, flotation, reproduction and protection of one specific marine algae.***

Field Site: Rocky coast and tidepools; some work in the classroom.

Materials:

- Various sizes of plastic bags
- Algae drawings in the pocket section of this unit
- One basic field kit for each group of five students (optional) which contains:

  30 centimeter ruler
  thermometer (°C)
  hand lens
  pencils
  pad
  putty knife

Timing: Allow two to three hours of actual activity time. Variable preparation and follow-up time would be needed in the classroom.

Procedure: This activity will help you and your students to focus on one aspect of the tidepool community. Discovery and observation will lead you to learning some basic facts about life as the marine algae live it. From there you can expand these basic ideas to general concepts about how one plant functions within a population and how that population may function within the total tidepool community.

Before you go to the shore you might have your students do some research on algae anatomies to see how they relate to other algae and land plants. Another suggestion is to have them read and report on the aspects of the different algae life histories. Both anatomy and life history diagrams are provided in the pocket section of this unit.

At the shore, divide your students into exploration groups and let them try several of these exercises.

A. Find some algae and first get acquainted. Be patient and sit quietly at the edge of a tidepool and watch for five minutes. Where do the algae lie?

   1. Where do the algae lie?
   2. What is the temperature of the air, the sea water and the tidepool water?

B. Separate one algae plant from the rest and learn about its anatomy...while it is still attached to the rock!

   1. Use a hand lens to study its holdfast, stem and blade(s). Is there anything living on it?
   2. Are there any other interesting structures on the plant? What are they called? Why do these seaweeds need these other structures? How large are they?
   3. Can you find any organism using the algae for protection?

C. Look at a section of algae and note how the individual plants live together.

   1. Distribute your groups along the shore from the high to low tide lines. Have each group mark off a four-sided (one meter square) area with the centimeter ruler. This area is called a 'quadrat.'
   2. Each exploration group should describe and record specifically the different types of algae they see in their quadrat.
   3. Now have every team count and record the numbers of each species in their plot.
   4. After gathering the data, compare each team's findings. In which zones were different species found? Why do their colors vary?
   5. Collect a few plants to be brought back to the classroom.

D. Back in the classroom try some of these activities.

   1. Talk about your data. Create graphs, murals or collages illustrating your findings.
   2. Press up the collected algae for use about the classroom.
   3. Plan some algae cooking and eating activities for all students to participate. This is done easier at home than in the classroom.

Teacher Resources

Other Northern New England Marine Education Projects to refer to....

for the different types of shores and an indepth look at coastal zonation ***Have You Been To The Shore Before?*** pages 2-6

for a good description of seaweed pressing ***Have You Been To The Shore Before?*** pages 9-11

for pre-trip planning to beaches and other field sites ***Have You Been To The Shore Before?*** pages 13-15

for organizational resources, resource persons, field sites ***Have You Been To The Shore Before?*** pages 23-33

for information on algae culture ***Is Our Food Future In The Sea?*** page 16

For further information contact:

Atlantic Laboratories
Waldoboro, Maine
(207) 563-5412
Robert Morse — proprietor
Gary Patzlaff — chemist

Atlantic Laboratories harvests seaweed and produces animal feed supplements and liquid fertilizer. While they do not provide group tours they may be very helpful in answering questions regarding seaweeds in industry.

Marine Colloids, Division of FMC Corporation
Crockett Point
Rockland, Maine
(207) 594-4436

Marine Colloids provides small group tours to people over 12 years of age and is a good example of the use of seaweed in industry. Group leaders should call first and inquire about the applicability of this company to the marine algae subjects being discussed.

Annotated Bibliography

Books

Arnold, A.F. ***The sea beach at ebb-tide.*** New York: Dover, 1968, 490 p.
The seaweeds and lower animal life found between tide-marks are identified and studied.

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This is a thorough treatment of the structure and reproductive processes of algae.

Boney, A.D. ***A biology of marine algae.*** London: Hutchinson Educational Ltd., 1966.
This is a very good summary of growth, life-histories, ecological tolerances, maintenance and seasonal behavior of algae.

Brown, J.E. ***Wonders of a kelp forest.*** New York: Dodd, Mead & Co., 1974. Grades 6-9.
The value and location of the great kelp forests are discussed. Inhabitors of the kelp beds are also presented.

Chapman, V.J. ***Seaweeds and their uses.*** London: Camelot Press Ltd., 1970.
Excellent book giving the history of the seaweed industry, and the distribution and uses of seaweeds.

Dawson, E.Y. ***How to know the seaweeds.*** Dubuque, Iowa: Wm. C. Brown, Company, 1956.
This is a standard field guide to the seaweeds; pictures, descriptions, and the use of an identification key are presented.

Fortner, Heather J. ***The Limu Eater: a cookbook of Hawaiian Seaweed.*** University of Hawaii Sea Grant College Program, 1978.
A good look at the Hawaiian Culture centered around their uses of the Pacific algae. Seaweed preparation and recipes are also provided.

Gibbons's E. ***Euell Gibbons's Beachcomber's Handbook.*** New York: David McKay Company, Inc., 1967.

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Provides a thorough look at the different species of seaweeds and invertebrates found along the Atlantic seashore. Presented in field guide form with pictoral reference plates.

Guberlet, M.L. ***Seaweeds at ebb tide.*** Seattle: University of Washington Press, 1956. 182 p.
A Pacific coast view of the seaweeds found between high and low tide marks.

Hillson, C.J. ***Seaweeds.*** Pennsylvania State University Press: Keystone Books, 1977.
This is an excellent guide book for the beginner or experienced botanist. The algae are identified by groups using color distinctions. Also some natural

history is given about each species. Only Atlantic coast species noted.

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Describes the current and possible future uses of algae.

Kingsbury, J.M. ***The rocky shore.*** Illus. by Norma, E. and Norma M. Chatham Press, Inc., 1970.
Land and sea flora and fauna of the New England coast are described in great detail. Some physical characteristics of the New England coast are also included.

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For the child who has access to the beach, this book offers suggestions for artistic and scientific activities. How to press seaweeds, how to make beach collages and mobiles are examples.

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Quantative studies of the world seaweed resources: assessment; harvesting — biomass, impact of practical and economic constituents, theoretically attainable harvest; relative distribution; ecological data.

The Uncommon Cookbook. Marine Sea Grant Bulletin, Darling Center; sponsored by NOAA Offices of Sea Grant, Dept. of Commerce, 1975.
Several recipes are given for the seaweeds that are found locally in the coastal areas of Maine.

Articles

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A description of the vegetation mentioned above by genus and species.

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Describes a method of constructing a chamber. The chamber is designed to grow marine tropical algae.

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Use of gallon jars and sea sediment to study algae blooms.

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The author discusses industrial uses of seaweed as well as classroom activities revolving around these weeds.

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A method of mounting marine algae using file cards and transparent food wrapping.

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Elseview North-Holland, Inc., New York
52 Vanderbilt Ave., New York, NY 10017
C. Dean Hartog, ed.
For advanced students.

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Sea Frontiers, a publication of the International Oceanographic Foundation, contains well illustrated articles of general interest on the marine environment.
The International Oceanographic Foundation, 3979 Rickenbacker Causeway, Virginia Key, Miami, Florida 33149.

Annotated Filmography

These (*) films are available through the Film Rental Library, Shibles Hall, University of Maine at Orono, Orono, Maine 04469. When ordering, be sure to include the film number, exact title and date(s) for use. Phone orders will be accepted (207-581-7541).

Algae (Indiana University) 1964 16 min. Color
This film characterizes the five major groups of algae: blue-green, green algae, diatoms, red algae, and brown algae. It explains sexual and asexual modes of algae reproduction and discusses various algae habitats as well as how man uses algae.

Life Cycle of the Rockweed (Fucus vesiculosis) (Harvard Film Service) appox. 10 min. Black & White.
Reproduction of the seaweed *Fucus*, presented in great detail. Examines anatomy of sexual parts, fertilization, and development. Useful only in a specialized course.

(*)***Life in the Sea*** S-501 11 min. Color
This film describes the interrelationships of plants and animals in providing a chain of food and maintaining a delicate balance of life. EBF 1958.

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A study of marine agriculture, a relatively new and undeveloped industry that is supplementing the fishing industry in the maritime provinces of Canada. Provides background on the general types of seaweed harvested, its industrial and popular uses, and the need for continued scientific research in the area of seaweed farming.

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The growth, harvesting and uses of seaweeds are filmed and reported, from the carrageenan used in chocolate milk to pharmaceutical products. Available through the University of Illinois Film Center, 1325 South Oak Street, Champaign, Illinois, 61820.

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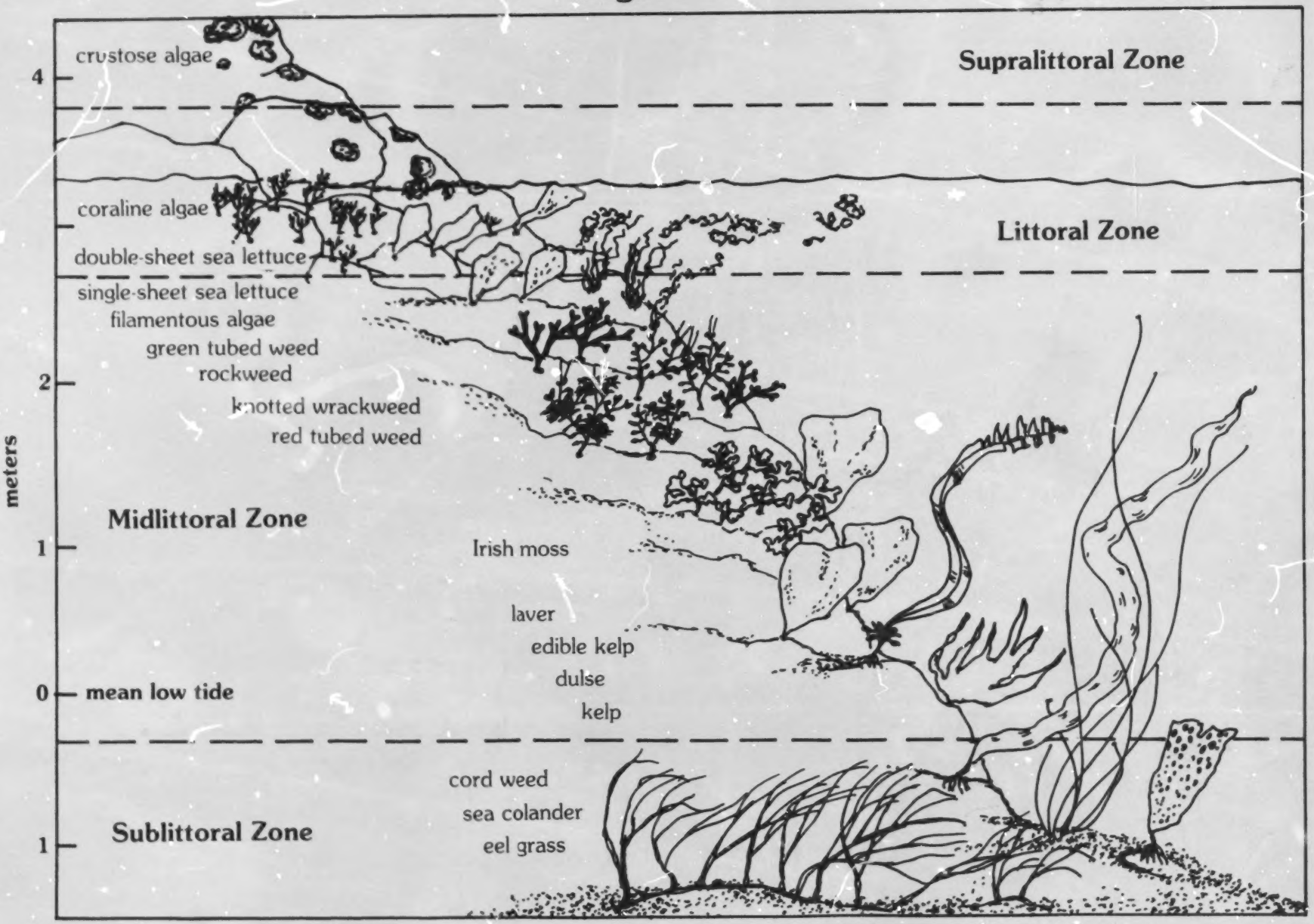
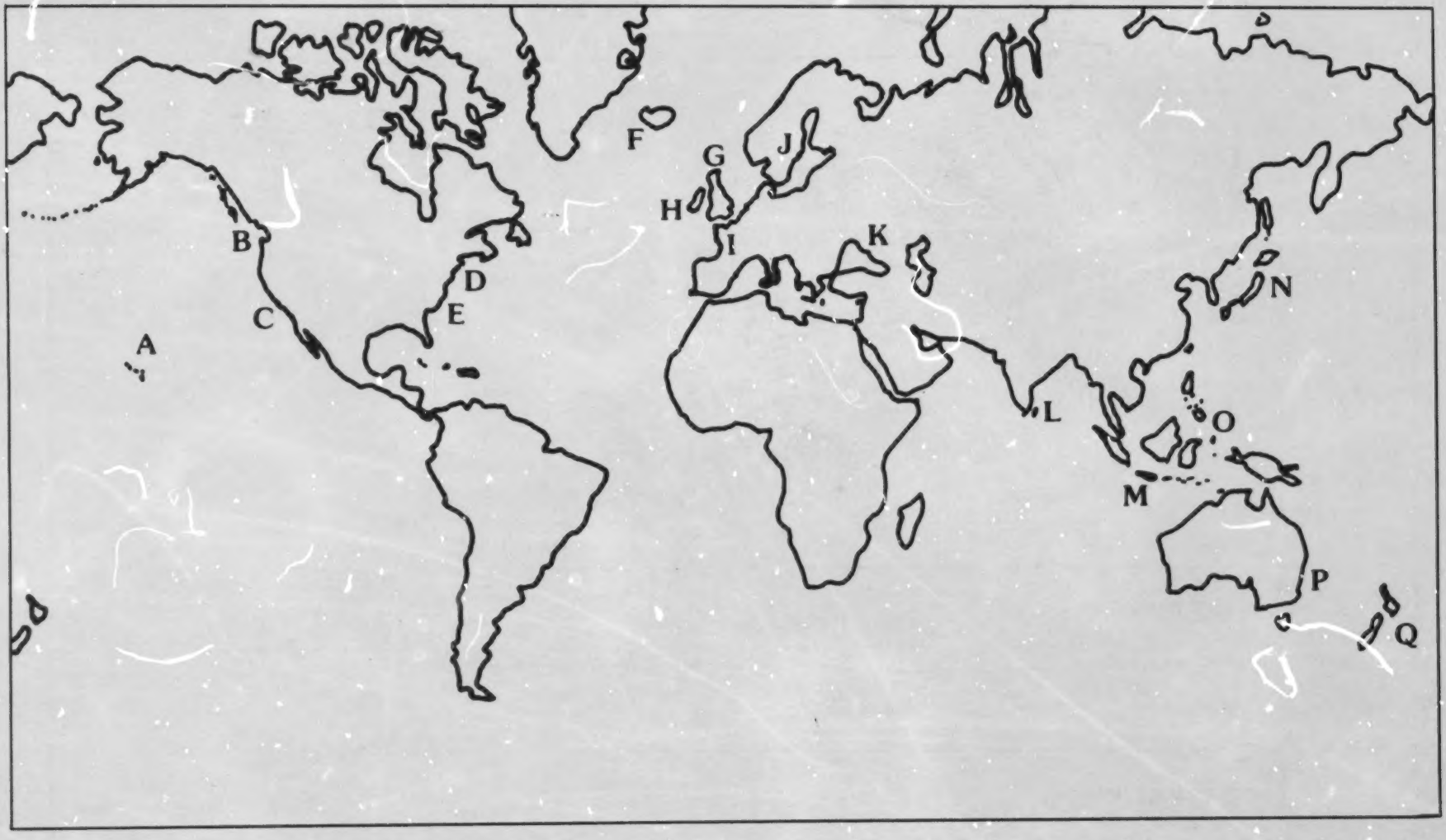
Algae Zones


crustose algae
Supralittoral Zone
4
coraline algae
Littoral Zone
double-sheet sea lettuce
single-sheet sea lettuce
filamentous algae
green tubed weed
rockweed
2
knotted wrackweed
red tubed weed
meters
Midlittoral Zone
1
Irish moss
laver
edible kelp
dulse
0
mean low tide
kelp
cord weed
sea colander
eel grass
Sublittoral Zone
1

Marine Algae World Map



An Identification Key to the Common Gulf of Maine Algae Species

proceed to #

1. What color is the algae? green 2
   red 4
   brown 8

2a. Is the plant body (thallus) a broad blade, solid throughout? 3

2b. Is the plant body tubed, narrow blade; hollow inside? ... ***Enteromorpha***

2c. Is the plant wiry, threadlike, in loose curls not collapsing flat when removed from water (like horsehair)? ..... ***Chaetomorpha***

3a. Is the blade firm; 2 cells thick if a microscope is available or fingerprints are undetectable through the plant when a finger is pressed to the opposite side? ..... ***Ulva***

3b. Is the blade delicate; 1 cell thick if a microscope is available or fingerprints are detectable through the plant when a finger is pressed to the opposite side? ..... ***Monostroma***

4a. Is the plant body hard and stony? 5

4b. Is the plant body neither hard or stony? 6

5a. Is the algae erect, branched or jointed? ..... ***Corallina***

5b. Is the algae flat, stony and encrusted upon (coating) mussels shells, stones or other algae? ..... ***Lithothamnion***

6a. Is the algae found growing as an epiphyte (one plant growing upon another) on *Ascophyllum*? ..... ***Polysiphonia***

6b. Is the plant body flattened with an unbranched blade; two or three cells thick (see easy test in #3 above); no midrib (thickened line of cells in the center of the blade) or veins (branches from the midrib) present? ..... ***Porphyra***

6c. Is the blade simple (unbranched), lobed (having rounded ends), or branched with veins and midrib absent? Is that thallus *several* cell layers thick (obvious to the unaided eye)? 7

7a. Does the thallus have two distinct regions: a compressed stalk or stipe and smooth, lobed, flattened dichotomously branched (forked) blades? Is its appearance mosslike? ..... ***Chondrus***

7b. Is the thallus flattened throughout without a distict stipe. Are the blades large with dichotomously branched lobes? Are there one to several outgrowths of branches? ..... ***Rhodymenia***

8a. Is the thallus branched? 9

8b. Is the thallus unbranched and in the shape of a cord or blade with no midrib present? 10

8c. Is the thallus an unbranched blade with a definite midrib present? 11

9a. Are the branches of the thallus flattened, usually dichotomously branched and producing a leaf-like blade? ..... ***Fucus***

9b. Are the branches of the thallus flattened, usually dichotomously branched, but not producing a leaf-like blade? ..... ***Ascophyllum***

10a. Is the plant composed of a definite blade with a complex "rootlike" holdfast (the organ of attachment), and a distinct cylindrical stipe that is longer than the blade width? ..... ***Laminaria***

10b. Is the thallus more or less a solid firm, slippery cord? ..... ***Chorda***

11a. Is the front (flat, leaflike blade) oval in shape with a perforated (full of holes) blade? ..... ***Aganum***

11b. Is the frond an elongated blade (long and narrow) with sporophylls (reproductive structures that look like small blades) along the stalk (between the blade and holdfast)? ..... ***Alaria***

The Marine Algae Field Guide of the More Common Gulf of Maine Algae Species

Greens — *Chlorophyta*

Sea Lettuce ('double-sheet')
Ulva lactuca

This common plant remains attached to rocks, woodwork, and coarse algae in exposed areas. The lettuce-like shape and texture of the blade is round, lobed and broad, and anchored by a small holdfast (*Ulva* has no stalk). Microscopically, the cells are as high as they are wide. *Ulva* is a yearly plant that grows to 6 diameters long or more.

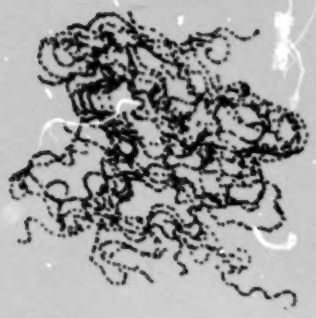
Sea Lettuce ('single-sheet')
Monostroma oxyspermum

Monostroma oxyspermum is another common seaweed that is often confused with *Ulva lactuca*. This plant prefers shallow waters and protected areas, and is found in the spring and summer months.

Monostroma feels weaker and thinner than *Ulva*, something like the consistency of tissue paper compared with wax paper. Certain indentification requires the use of a microscope but the following test can be used for easy field identification: finger prints can be clearly seen through the single-cell layer of *Monostroma* while they are distinctly visible through the double cell of thickness of *Ulva*.

Green tubed weed or hollow green weed
Entromorpha intestinalis

These plants are arranged singularly or in expanding bunches. At first, they remain attached to shells, stones, and woodwork, but later they often become free-floating. The color of this seaweed is yellowish-green with a membranous (filmy) texture. The frond narrows below, while above, the stalk is cylindrical and tubular. The length varies from 1 to 20 (or more) diameters tall and the width ranges from 1 mm. to 10 cm. *Entromorpha intestinalis* is found yearly in the lower intertidal zone and in tide pools.



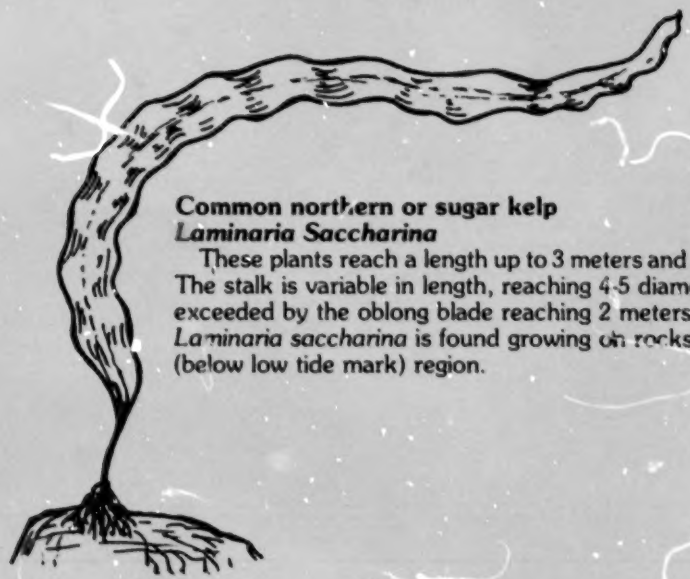
Filamentous algae
Chaetomorpha linum

These plants form loosely entangled, unattached filaments (threads). They are yellowish-green, and somewhat stiff and curled. The cells are cylindrically arranged and are from one to two diameters long. These plants are commonly drifted ashore in large masses, often entangled with coarse algae.

Browns — *Phaeophyta*

Smooth cord weed
Chorda filum

Chorda filum is a slender, whip-like, brown seaweed lacking branches. Its core is hollow, thus allowing the plant to remain buoyant in the water. Smooth cord weed grows to 4.5 meters (15 feet) and is hardly more than 6 mm. (1/4 in.) thick. This plant grows annually and is mature in late summer.

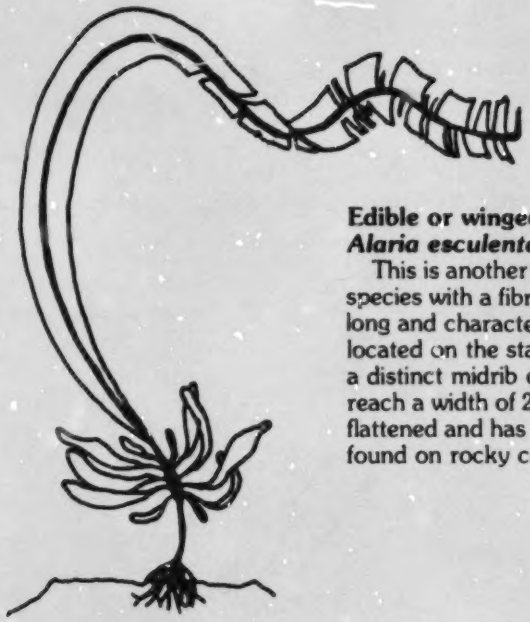


Common northern or sugar kelp
Laminaria Saccharina

These plants reach a length up to 3 meters and a width up to 20 cm. The stalk is variable in length, reaching 4-5 diameters, and is greatly exceeded by the oblong blade reaching 2 meters or more in length. *Laminaria saccharina* is found growing on rocks in the sublittoral (below low tide mark) region.

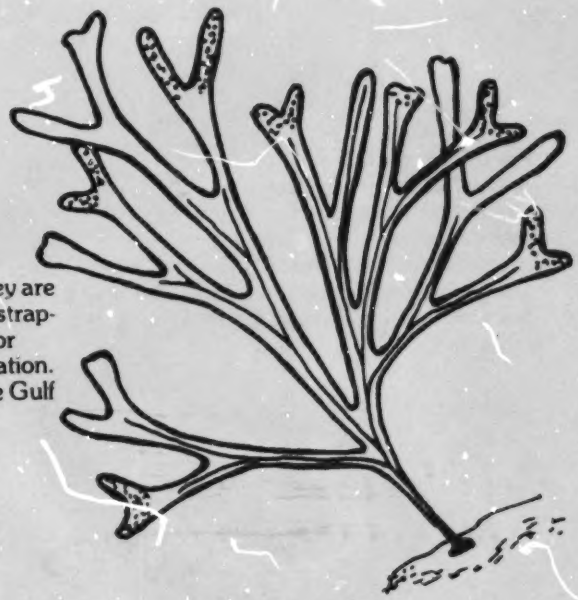
Horsetail or oarweed kelp
Laminaria digitata

The horsetail kelp is a perennial plant (lasting for years) ranging in size to 3 meters. It is attached by a heavy, fibrous holdfast and a stout stalk that shows growth rings in well-developed sections. The blade is widely spreading and when mature 10-30 or more narrow, flat segments of moderately thick texture are seen. This seaweed is naturally found growing below tide level attached to exposed rocky substrates.



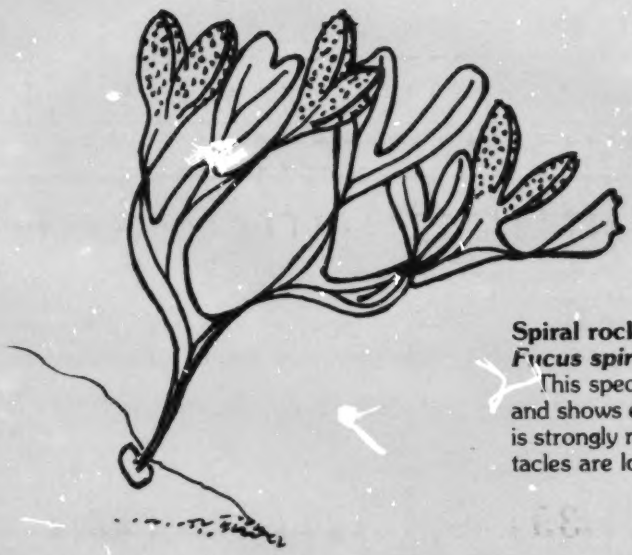
Edible or winged kelp
Alaria esculenta

This is another perennial plant of moderate size. *Alaria* is a narrow species with a fibrous holdfast supporting a stalk that is 1-3 diameters long and characterized by wide and flat fruiting rachis (short blades) located on the stalk. At full maturity the vegetative blade is seen with a distinct midrib of 5-10 mm. or more in width. The blade itself may reach a width of 25 cm. and a length of 3 diameters. The entire plant is flattened and has a thin, ruffled, membranous border. Alaria is usually found on rocky coasts and can be easily eaten raw.



Rockweed
Fucus sps.

These plants are erect from a discoid or irregular holdfast. They are usually dichotomously branched (forked), and the branches are strap-shaped with a more or less distinct midrib. Air-filled bladders, or receptacles, are usually present for buoyancy and easy identification. *Fucus* species can be found at and below the low tide mark in the Gulf of Maine.

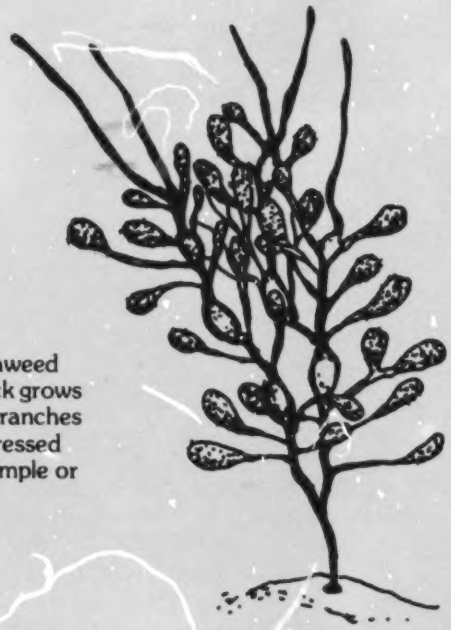


Spiral rockweed or flat wrackweed
Fucus spiralis

This species of rockweed is from 1.5 to 3.0 diameters tall, bushy, and shows erect, twisted branches. This plant is of average width and is strongly ribbed below, while above, simple or forked terminal receptacles are long, oval and swollen.

Bladder wrack
Fucus vesticulosus

Generally from 3 to 9 diameters tall, this plant is attached by an unbranched holdfast. The above branches are strap-shaped and display a marked midrib throughout. The vesicles (bubbles) are paired on each side of the midrib. At the terminal region of the branches are the broadly swollen receptacles that may be single, paired, or forked.



Knotted wrack weed
Ascophyllum nodosum

Another common plant to the low-low tide region, this seaweed reaches a large size of from 3 to 6 diameters. The knotted wrack grows erect from a discoid holdfast, and the main axis and principle branches are compressed with large, single, flat bladders. Short compressed branchlets are present in groups or singularly, and they are simple or forked.

Sea colander kelp or devil's apron
Agarum cribrosum

These plants are attached by a fibrous holdfast branching to a short slender stalk (2-5 cm.). The single, oblong, perforated blade is divided along the center line by a strong compressed midrib. The plant is of moderate size and can be found in the intertidal zone.

Reds — *Rhodophyta*

Red tubed weed
Polysiphonia lanosa

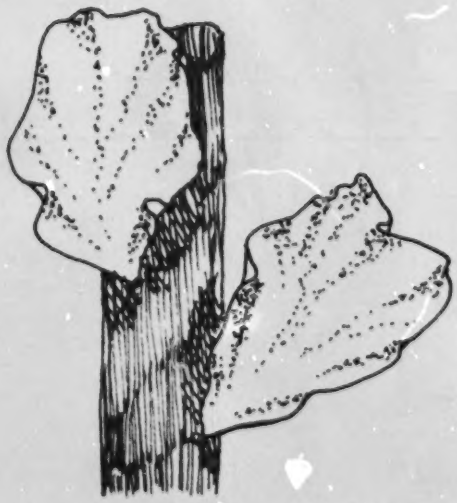
This species grows only as an epiphyte (one plant growing upon a plant) on *Ascophyllum*, and accompanies it in the intertidal zone (the area between high and low tides). This epiphyte may reach a height of 5 cm. and is well protected by the over-hanging masses of *Ascophyllum*.

Irish moss or sea moss
Chondris crispus

Irish moss plants have several blades and are attached by a discoid holdfast. They grow from 8 to 15 cm. tall and form loose to often dense clumps. The entire plant is a darkened-purple color when fresh. Its segments are blade-like, usually somewhat closely divided and "crisped" in the top segments. These segments range in width from 2 to 15 mm. *Chondris crispus* grows throughout the year on rocks, shells, or woodwork, and in tidepools or in the intertidal region.

Coral weed
Corallina officinalis

The coral weeds grow to 12 cm. tall and are tufted or crested. The calcified basal disc spreads along the substratum, and branching is usually oppositely pinnate (feather-like with branchlets on either side of the axis). This species is found growing on rocks and in tide pools.



Laver
Porphyra umbilicalis

Porphyra is an olive to brownish-purple colored plant that grows to a large size; 1 to 3 diameters long and 0.5 to 3.0 diameters wide. Generally, it is a broad plant about a rounded or discoid holdfast with its upper portions entire or divided into broad lobes. It is a soft, nearly flat, rubbery plant with a membranous texture found growing on rocks from the intertidal region.

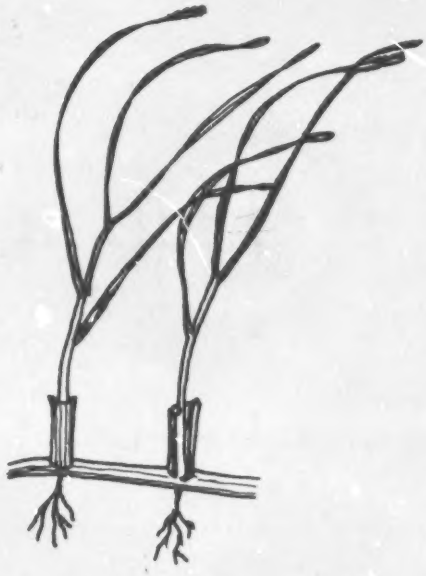
Dulse
Rhodymenia palmata

Arising from a small, discoid holdfast, this large plant grows either in small colonies or solitary. It is simple below, and the blade gradually expands into broad segments that are palmatelly (representing a palm branch) divided. The color is purplish-red and the plant's texture is a membranous leather. Reaching a total height to 5 diameters and a width to 16 cm. above, 7 cm. below, this seaweed forks above into strap-shaped divisions. The dulse is found growing from the intertidal area down into deep water.

Crustose algae
Phymatolithon and Lithothamnion species

These encrusting-algae species form stony to chalky crusts, ranging from thin and glaze-like to huge, knobby, or branching structures. Calcium carbonate ($CaCO_3$) is the compound that gives these plants their solid exterior. Both species form heavy crusts usually on rocks or large mussel shells. Their colors are a vivid white to rose or purple. These algae are found in all tidal regions, depending upon the substrate (surface of plant attachment).

Seed Plants



Eel grass
Zostera marina

Eelgrass is a marine seed plant related to the freshwater pondweeds. Its leaves are from 6 to 12 mm. wide and up to 900 mm. (3 ft.) long. Zostera grows from a creeping runner that sends up leafy stems at different intervals. This plant will produce a flower in late spring to early summer. It commonly lives on tidal mud flats and in bays and estuaries from low tide level down to 7 meters or more. Zostera is a plant of great ecological importance, as well as an important food of birds and many marine animals.

A	L	G	A	E
air bladder	green tubed weed	branches	egg	sub-littoral zone
Irish moss	midrib	littoral zone	dulse	blade
smooth cord weed	frond	FREE	common northern kelp	sporophylls
edible kelp	spore	epiphyte	mid-littoral zone	laver
stipe	knotted wrack weed	thallus	zygote	horsetail kelp

A	L	G	A	E
laver	stipe	sea colander	epiphyte	holdfast
frond	cells	blade	red tubed weed	spore
littoral zone	edible kelp	FREE	thallus	vein
midrib	lobes	sea lettuce	sporophylls	dulse
rockweed	Irish moss	egg	coral weed	supra-littoral zone

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A	L	G	A	E
sea lettuce	mid-littoral zone	horsetail kelp	green tubed weed	cells
vein	coral weed	holdfast	edible kelp	smooth cord weed
spore	sea colander	FREE	lobes	red tubed weed
branches	common northern kelp	laver	blade	supra-littoral zone
sub-littoral zone	zygote	rockweed	knotted wrack weed	air bladder

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A	L	G	A	E
common northern kelp	egg	Irish moss	lobes	stipe
holdfast	laver	vein	sub-littoral zone	edible kelp
thallus	sporophylls	FREE	sea colander	frond
green tubed weed	littoral zone	dulse	midrib	epiphyte
cells	branches	zygote	rockweed	knotted wrack weed

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Algae Boards

A	L	G	A	E
dulse	supra-littoral zone	sporophylls	air bladder	midrib
horsetail kelp	epiphyte	green tubed weed	frond	sea colander
zygote	sea lettuce	FREE	spore	branches
blade	smooth cord weed	stipe	Irish moss	mid-littoral zone
coral weed	thallus	common northern kelp	vein	lobes

A	L	G	A	E
egg	dulse	lobes	stipe	rockweed
red tubed weed	vein	smooth cord weed	branches	Irish moss
epiphyte	sub-littoral zone	FREE	sea colander	thallus
mid-littoral zone	holdfast	midrib	sea lettuce	common northern kelp
sporophylls	horsetail kelp	air bladder	cells	green tubed weed

A	L	G	A	E
supra-littoral zone	blade	edible kelp	spore	sea lettuce
horsetail kelp	rockweed	frond	laver	egg
thallus	red tubed weed	FREE	smooth cord weed	littoral zone
sporophylls	mid-littoral zone	knotted wrack weed	holdfast	coral weed
dulse	air bladder	cells	common northern kelp	zygote

A	L	G	A	E
sea colander	epiphyte	sub-littoral zone	horsetail kelp	blade
lobes	air bladder	coral weed	stipe	branches
knotted wrack weed	zygote	FREE	laver	rockweed
littoral zone	cells	red tubed weed	supra-littoral zone	Irish moss
midrib	green tubed weed	spore	edible kelp	vein

Algae Boards

A's.

A L G A E word/phrase list for the letter A

A MIDRIB
A VEIN
A AIR BLADDER
A STIPE
A FROND
A BLADE
A HOLDFAST
A SPORE
A EGG
A ZYGOTE
A CELLS
A LOBES
A THALLUS
A BRANCHES
A EPIPHYTE
A SPOROPHYLLS
A IRISH MOSS
A HOLLOW GREEN WEED
A COMMON NORTHERN KELP
A EDIBLE KELP
A KNOTTED WRACK WEED
A SEA COLANDER
A DULSE
A SEA LETTUCE
A SMOOTH CORD WEED
A HORSETAIL KELP
A ROCKWEED
A TUBED WEED
A CORAL WEED
A LAVER
A LITTORAL ZONE
A SUBLITTORAL ZONE
A SUPRALITTORAL ZONE
A MIDLITTORAL ZONE

L's

A L G A E word/phrase list for the letter L

L MIDRIB
L VEIN
L AIR BLADDER
L STIPE
L FROND
L BLADE
L HOLDFAST
L SPORE
L EGG
L ZYGOTE
L CELLS
L LOBES
L THALLUS
L BRANCHES
L EPIPHYTE
L SPOROPHYLLS
L IRISH MOSS
L HOLLOW GREEN WEED
L COMMON NORTHERN KELP
L EDIBLE KELP
L KNOTTED WRACK WEED
L SEA COLANDER
L DULSE
L SEA LETTUCE
L SMOOTH CORD WEED
L HORSETAIL KELP
L ROCKWEED
L TUBED WEED
L CORAL WEED
L LAVER
L LITTORAL ZONE
L SUBLITTORAL ZONE
L SUPRALITTORAL ZONE
L MIDLITTORAL ZONE

G's

A L G A E word/phrase list for the letter G.

G MIDRIB
G VEIN
G AIR BLADDER
G STIPE
G FROND
G BLADE
G HOLDFAST
G SPORE
G EGG
G ZYGOTE
G CELLS
G LOBES
G THALLUS
G BRANCHES
G EPIPHYTE
G SPOROPHYLLS
G IRISH MOSS
G HOLLOW GREEN WEED
G COMMON NORTHERN KELP
G EDIBLE KELP

G KNOTTED WRACK WEED
G SEA COLANDER
G DULSE
G SEA LETTUCE
G SMOOTH CORD WEED
G HORSETAIL KELP
G ROCKWEED
G TUBED WEED
G CORAL WEED
G LAVER
G LITTORAL ZONE
G SUBLITTORAL ZONE
G SUPRALITTORAL ZONE
G MIDLITTORAL ZONE

E's

A L G A E word/phrase list for the letter E

E MIDRIB
E VEIN
E AIR BLADDER
E STIPE
E FROND
E BLADE
E HOLDFAST
E SPORE
E EGG
E ZYGOTE
E CELLS
E LOBES
E THALLUS
E BRANCHES
E EPIPHYTE
E SPOROPHYLLS
E IRISH MOSS
E HOLLOW GREEN WEED
E COMMON NORTHERN KELP
E EDIBLE KELP
E KNOTTED WRACK WEED
E SEA COLANDER
E DULSE
E SEA LETTUCE
E SMOOTH CORD WEED
E HORSETAIL KELP
E ROCKWEED
E TUBED WEED
E CORAL WEED
E LAVER
E LITTORAL ZONE
E SUBLITTORAL ZONE
E SUPRALITTORAL ZONE
E MIDLITTORAL ZONE

Extra A L G A E word/phrase list

MIDRIB
VEIN
AIR BLADDER
STIPE
FROND
BLADE
HOLDFAST
SPORE
EGG
ZYGOTE

CELLS
LOBES
THALLUS
BRANCHES
EPIPHYTE
SPOROPHYLLS
IRISH MOSS
HOLLOW GREEN WEED
COMMON NORTHERN KELP
EDIBLE KELP
KNOTTED WRACK WEED
SEA COLANDER
DULSE
SEA LETTUCE
SMOOTH CORD WEED
HORSETAIL KELP
ROCKWEED
TUBED WEED
CORAL WEED
LAVER
LITTORAL ZONE
SUBLITTORAL ZONE
SUPRALITTORAL ZONE
MIDLITTORAL ZONE

Sample Number	Invented Name	Sample Number	Names and Characteristics

35

48

49

Marine Algae Game Score Forms

Sample Number	Invented Name

Sample Number	Names and Characteristics

36

Create an Algae Challenge Cards

Create an algae that looks like the moss that grows on land.

Create an algae that you would like to see growing in a salt-water aquarium.

37

Create an algae with "armor" protection.

Create an algae that would look good enough to eat in a salad.

Create An Algae Challenge Cards

Create an algae that can hold on to rocks in swift currents.

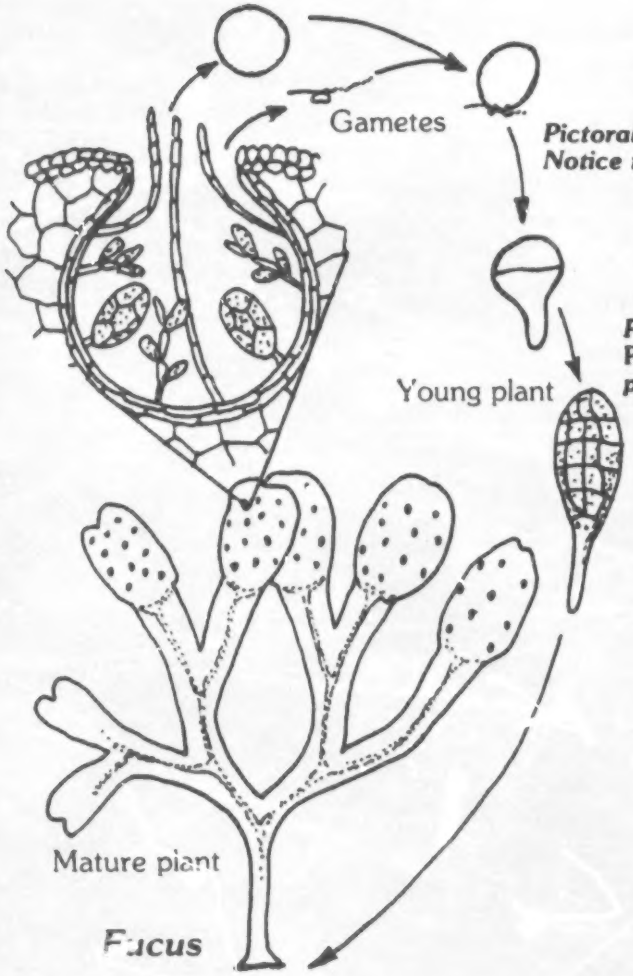
Create an algae that can live without any bottom attachment.

38

Create an algae that can live without water for 2-4 hours.

Create an algae that grows in deep water. (Hint: all algae need sunlight)

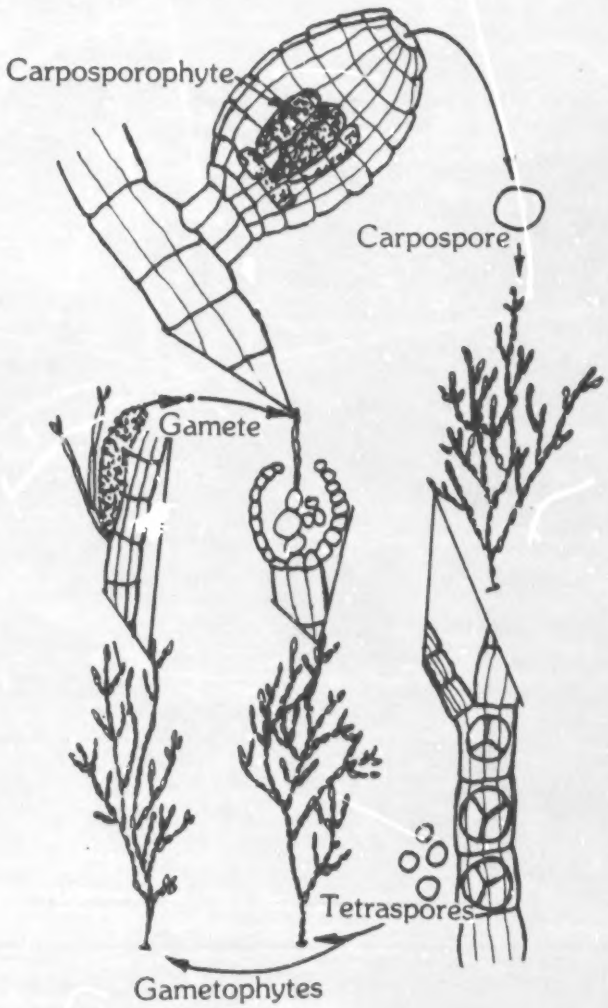
Life History Diagrams



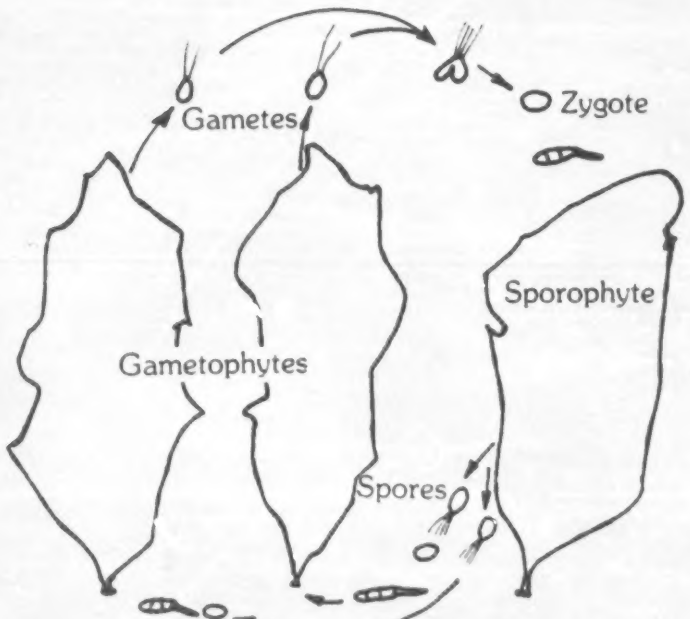
Fucus

Pictoral description of the life history of rockweed,* Fucus. *Notice the size differences of the gametes (oogamy).

Pictoral description of the life history of the red tubed weed* Polysiphonia. *Notice the alternation of generations and the production of tetraspores from the tetrasporophyte.



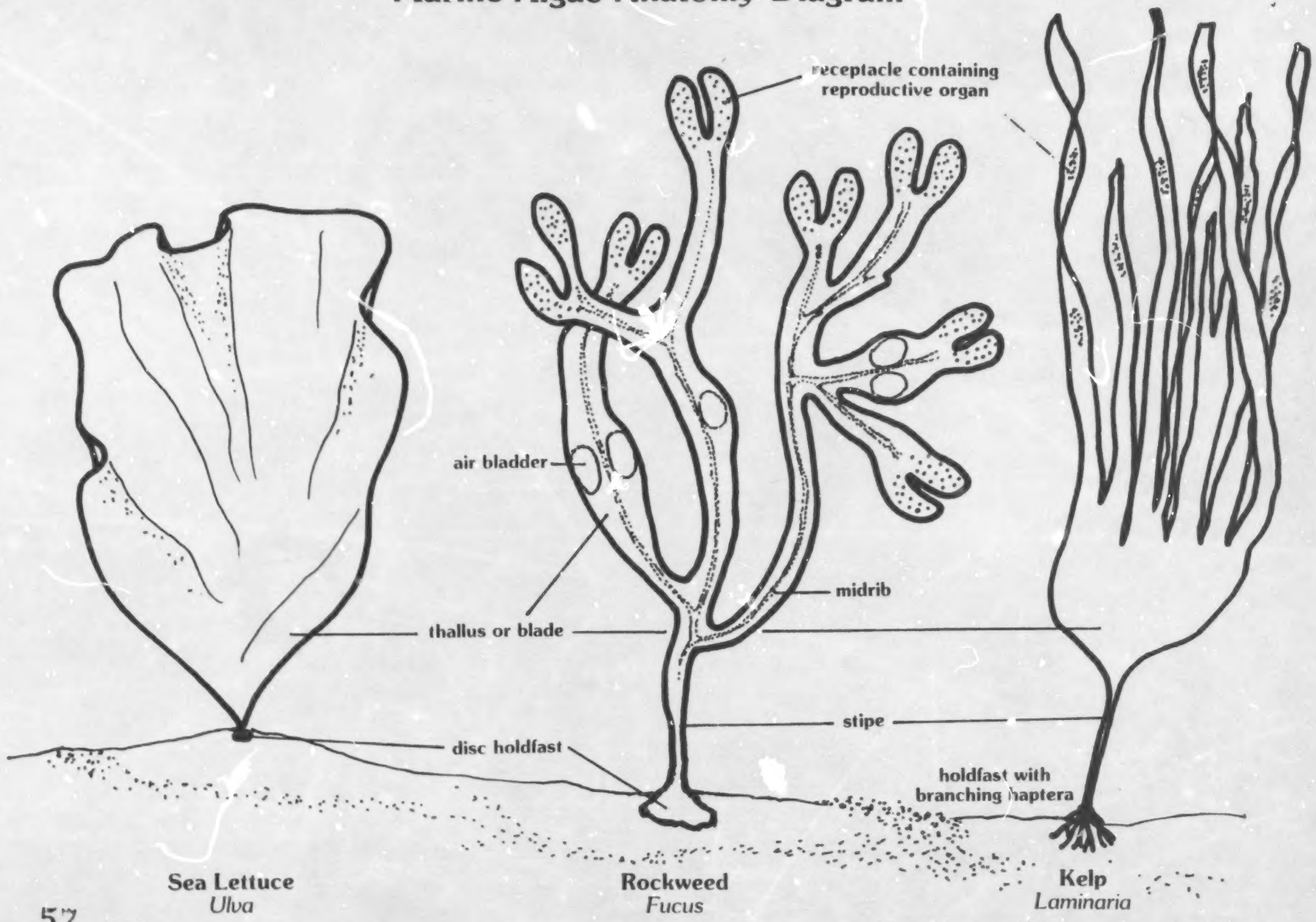
Polysiphonia



Ulva

Pictoral description of the life history of sea lettuce,* Ulva. *Notice the development of alternation of generations.

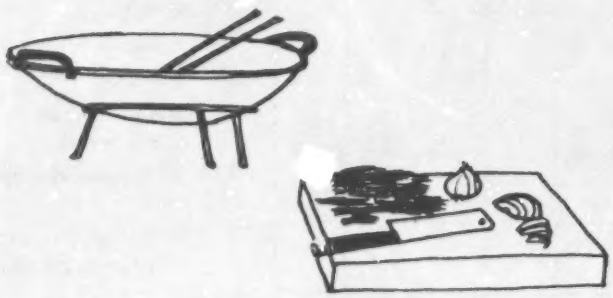
Marine Algae Anatomy Diagram



Further Marine Algae Epicures

Salad Recipe

This salad is prepared with several members of green algae. Sea lettuce *(Ulva)* is required as well as plants from the related green tubed weed, (genus *Enteromorpha*) plus the more delicate green plants of *Monostroma*.



Stir-Fried Irish Moss

250 ml fresh (or 125 ml dried) Irish moss
60 ml peanut oil
60 ml sesame oil
Thoroughly wash the Irish moss in cold water, drain and dry. Next, soak the plants for about 30 minutes in enough cold water to cover. Drain the water and remove any foreign matter from the Irish moss. Chop into bite-size pieces.

In a skillet, or 'wok' heat the oil. Quickly stir-fry the plants, until tender, in a mixture of the two oils. Serve with sea lettuce salad and seaweed bread if desired.

Stuffed Laver Fronds

dried laver fronds (leaflike part)
500 ml cooked rice
100 g raw ground beef
5 ml monosodium glutamate
25 g mushrooms, coarsely chopped
soy sauce

Drop laver fronds in boiling water for one minute or until soft. Combine all other ingredients for stuffing. Roll a tablespoon of stuffing into each frond and place in a steamer. Pour two cups of boiling water over the total and steam slowly for 50 minutes.

Moss Cheese

85 ml Irish moss
500 ml water
1 liter sour milk or 500 ml soy milk
5 ml ground celery seed
250 ml stewed tomatoes, pureed
15 ml parsley, minced
Boil Irish moss in water for 20 minutes. Cool. Mix with the sour milk or soy milk. Pour into muslin bag or two layers of cheesecloth to drain off whey. Empty solid cheese into bowl and beat in remaining ingredients. Pour into a shallow pan and cut into squares when set.

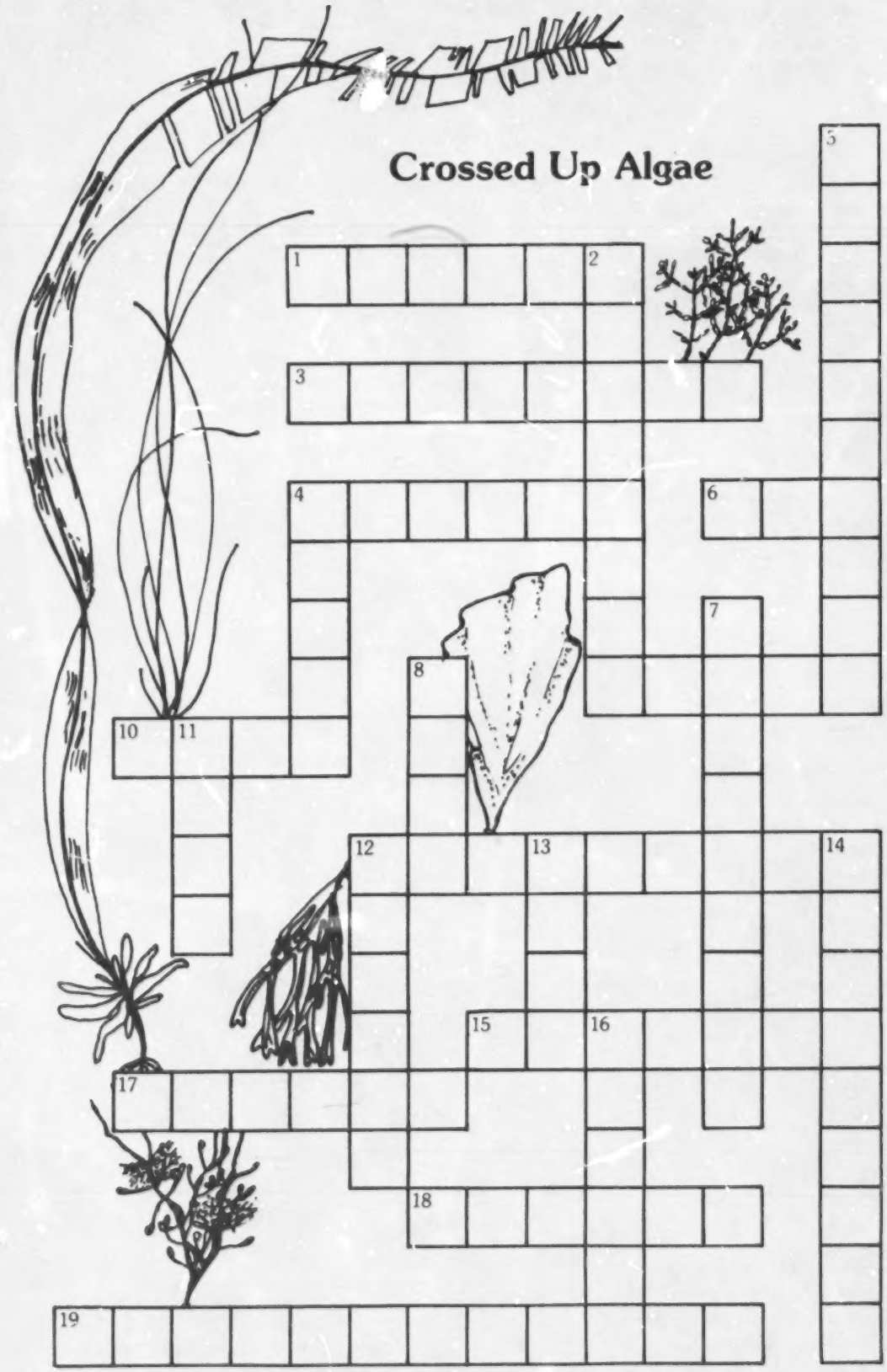
Seaweed Bread

Thoroughly rinsed and dry seaweed
Substitute water for milk
15 ml butter
Omit salt
Use a regular bread recipe. Grind or powder seaweed into a flour and substitute this seaweed flour for half the amount of flour called for by the recipe. Follow the rest of the substitutions or omissions and experiment with different seasoning.

Blanc Mange

Soaking the Irish moss in enough cold water to cover, drain and pick over. Add milk. Cook in double boiler 30 minutes. The milk will seem only slightly thickened, but if cooked longer the blanc mange will be too stiff. Add salt, strain, add vanilla and restrain. Fill individual molds previously dipped in cold water. Chill. Turn molds onto a glass dish and surround with thin slices of banana and place a slice on each mold. Serve with sugar and cream.

Crossed Up Algae



Across

1. Sea lettuce and green tubed weed
3. Root-like structure
4. Fertilized egg
6. To consume algae
9. Stemlike structure
10. Laver, dulse and coral weeds
12. *Chondrus crispus*
15. Sex cells
17. Rockweed, kelp and wrack weed
18. Male reproductive cells
19. Edible ocean plants, in general (2 words)

Down

2. Marine Algae
5. *Ulva lactuca;* _____
4. Regions where algae grow
7. Used in manufacturing dynamite
8. Gelling substance
11. Female reproductive cells
12. Medicine from marine algae
13. Used in making glassware and soap
14. Surface for algae attachment
16. Central vein of cells

Test on Marine Algae

1. What are the three kinds of marine algae and what makes each one so different?

   A.

   B.

   C.

2. Name two of the things that industries remove from algae. What is each one used for?

3. Fill in the diagram. Tell what function or use each part has.

Part

a _____

b _____

c _____

d _____

e _____

Function

A.

B.

C.

D.

E.

4. Using the **zonation diagram** list those algae common to the zones listed below. Why are they common to that zone?

   Supralittoral Zone:

   Littoral Zone:

   Midlittoral Zone:

   Sublittoral Zone:

5. From the **world map** name the region or country that belongs to a letter and tell how algae is used in that country.

6. What is the name of the marine algae in this picture? What color is it? Why do people collect this algae?

Products In Which Algin Is Used

Pharmaceutical products
Aureomycin tablets
Triple sulfa tablets
Terramycin suspensions
Penicillin suspensions
Anti-acid tablets
Sulfa suspensions
Aspirin compound tablets
Calamine lotion
Hemostatic powders
Bulking laxatives
Toothpaste
Dental impression compounds
Orthopedic impression
Surgical jellies
Suppositories
Mineral oil emulsions
Rubbing ointment
Soap

Textile products
Textile print pastes
Plastic laundry starch
Size compounds for cotton & rayon

Dairy products
Ice cream
Dry ice cream mix
Sherbert
Chocolate milk
Chocolate toddy
Sterilized cream

Miscellaneous food products
Bakery icings and meringues
Salad dressings
Frozen foods
Fountain syrups
Orange concentrates
Candy
Puddings

Adhesives
Wall board
Paper bags
Shipping containers
Gummed tape & decals

Paper products
Food packages
Milk containers
Butter cartons
Frozen food packages
Insulation board
Food wrappers
Greaseproof paper
Acoustical tile

Rubber
Natural & synthetic
Latex creaming
Automobile carpeting
Electrical insulation
Babies' rubber pants
Rubber coating
Foam coating
Tires

Miscellaneous products
Paints
Ceramic glazes
Porcelain ware
Leather finishes
Auto polishes
Welding rod coatings
Boiler compounds
Battery plate separators
Wallboard joint cement
Beet sugar processing
Wax emulsions

Sea Moss (Irish moss or *Chondrus crispus*) *landings in Maine*

Kilograms	*(pounds)*	*percent*	*$$*	*County*	*Year*
1,059,091	(2,330,000)		93,200		1975
318,000	(838,200)	21.0	33,528	Cumberland	
37,045	(81,500)	2.0	3,260	Hancock	
40,000	(88,000)	2.2	3,520	Knox	
257,409	(566,300)	14.2	22,652	Lincoln	
511,818	(1,126,000)	28.2	45,040	Sagadahoc	
590,909	(1,300,000)	32.5	52,000	York	
1,818,182	(4,000,000)	*	160,000		1976
522,277	(1,215,010)		83,157		1978
404,545	(890,000)	**	51,400		1979
136,364	(300,000)	33.7	7,340	Cumberland Hancock Knox	
40,909	(90,000)	10.1	5,160	Lincoln	
90,909	(200,000)	22.5	11,560	Sagadahoc Washington	
136,364	(300,000)	33.7	17,340	York	
459,090	(1,010,000)	***	60,600		1980

* 42.0 percent increase from 1975
** 36.5 percent decrease from 1978
*** 13.5 percent decrease from 1978

Major Algal Gum Applications in the Food Industry

Dairy	*Agar*	*Carra-geenan*	*Alginates*
Ice cream stabilizer	x	x	x
Ice milk	x	x	x
Milk shake	x	x	x
Sherbets	x	x	x
Ice pops & water ices	x	x	x
Chocolate milk drink		x	x
Instant puddings		x	x
Flavored milk drinks		x	x
Cooked puddings	x	x	x
Eggnog mix		x	
Variegating syrups		x	
Cottage cheese		x	x
Neufchatel-type cheese	x	x	x
Cream cheese	x	x	x
Cheese spread		x	x
Whipped cream		x	x
Yogurt	x	x	
Packageable milk/cream	x		
Beverages			
Soft drinks		x	x
Fruit juices		x	x
Beer foam stabilizer		x	x
Beer clarification		x	x
Fining wines etc.	x	x	x
Aging of spirits		x	
Bakery			
Bread doughs	x	x	
Cake batters	x	x	
Fruit cakes		x	
Doughnuts		x	
Pie fillings	x	x	x
Fruit fillings		x	x
Bakery jellies	x	x	x
Boiled cream fillings		x	x
Doughnut glaze	x	x	x
Flat icings	x	x	x
Meringues	x	x	x
Cookies	x		
Batter & breading mixes		x	
Citrus oil emulsions		x	x
Cake fillings & toppings	x	x	x
Frozen pie fillings		x	

Confectionary	*Agar*	*Carra-geenan*	*Alginates*
Candy gels	x		x
Caramels, nougats		x	
Marshmallows	x		
Dressings, sauces			
French dressing		x	x
Salad dressing		x	x
Syrups, toppings		x	x
Relish		x	x
White sauces		x	x
Mustard, cocktail sauces		x	x
Catsup		x	x
Dietetic foods			
Starch free desserts	x	x	
Salad/French dressing		x	x
Jellies, jams		x	x
Syrups		x	x
Puddings		x	x
Sauces		x	x
Icings			x
Candies			x
Vegetable & health foods	x		
900 calorie foods		x	
Meat, fish			
Sausage casing	x		x
Fish preservation			x
Canned fish, meat, etc.	x	x	x
Coated jellied meat		x	x
Antibiotic ice		x	
Sausage ingredient		x	
Preservative meat coat	x	x	x
Synthetic meat fibres		x	x
Miscellaneous			
Dessert water gels	x	x	x
Jams, preserves	x	x	x
Prepared cereals	x		
Processed baby food		x	
Soups	x	x	x
Coating fruits, vegs.		x	
Frozen foods		x	
Synthetic potato chips			x
Fountain toppings		x	x
Artificial cherries			x

Seaweed Harvester Licenses. 1973 to 1979

Year	*Number of Seaweed Harvester Licenses Issued*
1973*	114
1974	260
1975	285
1976	136
1977	140
1978	104
1979	75

** In 1973 approximately 16,000 Marine Harvester licenses were issued.*

Northern New England Marine Education Project

The objective of NNEMEP is to encourage and support marine education among the teachers of Northern New England so that their students will appreciate the importance of water in their lives and in the life of the planet. The project has received support from the College of Education of the University of Maine at Orono, the National Science Foundation, and the Maine-New Hampshire Sea Grant Program.

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